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DEPARTMENT OF THE INTERIOR,

CENSUS OFFICE.

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Appointed November 4, 1881. Office of Superintendent abolished March 3, 1885.

STATISTICS OF POWER AND MACHINERY USED IN MANUFACTURES.

REPORT

ON

MACHINE-TOOLS AND WOOD-WORKING MACHINERY,

BY

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AND
SPECIAL AGENT TENTH CENSUS.

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D. C., August 27, 1885.

Hon. L. Q. C. LAMAR,
Secretary of the Interior.

SIR: I have the honor to transmit herewith a report on shop-tools and wood-working machinery, prepared under the direction of Professor W. P. Trowbridge, of Columbia College, New York, N. Y., late a chief special agent of the Census Office, by F. R. Hutton, M. E.

Very respectfully,

J. H. WARDLE,
Chief of Census Division.

LETTER OF TRANSMITTAL.

NEW HAVEN, CONN., *September* 25, 1882.

Hon. CHARLES W. SEATON,
Superintendent of Census.

SIR: I have the honor to transmit herewith the report of Mr. F. R. Hutton, special agent of the Census, on Shop-tools, Wood-working Machinery, etc.

The two features of greatest interest and importance in American manufacturing industries are the development and general introduction of the principle of interchangeability in the parts of machines and implements manufactured and employed in the country, and the gradual introduction into our machine-shops and factories of special tools for preparing and shaping materials for the special uses which they are to subserve, either as parts of such machines or implements, or for general use.

These two branches or lines of development are closely related to each other, and have exercised an immense influence in the rapid growth of our national interests. It may be said of both that they had their origin in the characteristic inventive genius of our people, which has been wisely fostered by the national legislature through liberal patent laws enacted from time to time.

Within the memory of men now living, a New England farmer has devoted his winter evenings to the making of wooden clocks, for sale, his implements being a knife, a file, and a saw; another has devoted himself, with the aid of his family, to covering buttons by hand; the modest products in each case going far toward the support of the family.

The same processes are now accomplished, with slight changes in style and materials, on a large scale in extensive establishments provided with special tools which render hand-work almost unnecessary. These are mere instances to illustrate the changes that have taken place in every branch of human labor through the introduction of special devices now employed in manufacturing.

In the treatment of the materials which form the heavier metallic parts of engines and other machinery, and all varieties of wood-work, the advance has been no less remarkable. Operations now performed at small cost in preparing such materials for use would have been found impossible a few years ago by mere hand-work, or would at least have been impracticable on account of the great expense involved.

It may be affirmed, moreover, that with the multiplication of general and special tools in shops and factories there has been a corresponding advance in the strength, durability, and reliability of the machines and implements produced. The exact time-tables of our railway systems, fulfilled with such wonderful certainty at the present day, and the comparative immunity from stoppages and accidents of our manufacturing and mining machinery, would be unknown elements of modern activity if the machines employed were made wholly by hand.

The heavy operations now employed in welding, turning, boring, and shaping would be impracticable without the modern tools employed for these purposes. Without the steam-hammer the modern propeller-shaft for steamships could not be made, while there are hundreds of operations which, though possible by hand, are commercially practicable only through special tools.

Your wish that the subject of Shop-tools and Wood-working Machinery should receive attention in connection with the statistics of power and machinery led me to secure the services of Mr. F. R. Hutton, assistant in mechanical engineering in the School of Mines, Columbia College, New York, for this special work. Mr. Hutton's acquirements and fitness for this work were well known to me, and I now transmit his report, together with sketches, drawings, cuts, etc., relating to and illustrating the same.

The report will, I believe, be found worthy of a place in the records of the Tenth Census as illustrating the present period of our country's progress in the mechanic arts.

I have the honor to be, very respectfully, your obedient servant,

W. P. TROWBRIDGE,
Special Agent in charge, Tenth Census.

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LETTER OF TRANSMITTAL.

NEW YORK, *December* 8, 1881.

Prof. W. P. TROWBRIDGE.

SIR: I have the honor to transmit herewith the report upon Shop-tools, which I have prepared for the Tenth Census of the United States.

This report has been divided into two parts. The first part treats of tools for working metals, or machine-tools, properly so called. The second part treats of wood-working machinery. It was necessary to define the limits of classification in both divisions, in order that the expansion in the sub-classes should not carry the discussion into too broad a field. For this reason it was decided to begin with the materials as they are bought in the market. The tools for the fabrication of the metals into merchant forms are therefore excluded, and the forest sawing-machines for lumber. At the other end of the series, the line has been drawn at the tools which are distinctly special, or which are designed for one particular duty and can not be applied for any other. Between these boundaries, however, lies a very large class of machines which may be made of very wide application, according to the skill of their operators. These are the tools used in building other tools or constructions, and which, therefore, are more fundamental than they. They are, in short, the tools used in the constructive arts rather than in manufactures. Even with this limitation at both ends the field of study is still a wide one, and it is one in which American industry has been particularly active. The standard of mechanical excellence which is imposed by our best engineers demands a high standard in the tools for the construction of such work. The necessity for exact dimensions in machine-work has stimulated designers to arrange their material so that inaccuracy or spring shall be eliminated in the lines of tool travel. Fuller appreciation of the meaning of "bearing-surface" and its importance in tool-building makes the newer tools more durable as well as more exact. There are also other details of design and construction, which will be made evident from the illustrations in the sequel, which are confirmatory of the progress in this direction. It is hoped that the degree of advancement marked by the types discussed will serve as a stimulus to further effort and as a plane of reference to gauge the upward course in this particular during the next decade.

In the preparation of this report I obtained information at first-hand. Visits were paid to the leading centers of tool industry, and the details were ascertained from personal inspection. I would take this occasion to express my obligation to those gentlemen who have so kindly seconded my efforts in gathering accurate details. The uniform courtesy which it was my good fortune to enjoy in cities lying between Boston and Saint Louis has made the discharge of my duties particularly agreeable, especially when it is remembered that the collection of mechanical statistics of this sort is an entirely novel thing. In a very few cases only has information been gathered by correspondence and from catalogues. Catalogues are usually out of date before they are in circulation, and where they have been used care was taken to make sure of their accuracy.

The places visited are included in the list below. Many of them are the centers where many builders are to be found together, and are therefore of deserved importance:

In Connecticut: Danbury, Essex, Hartford, Middletown, New Haven, Norwich, Wolcottville.

In Delaware: Wilmington.

In Massachusetts: Boston, Chicopee, East Brookfield, Fitchburg, Greenfield, Hyde Park, Leeds, Lowell, New Bedford, Northampton, Springfield, Taunton, Westfield, Winchendon, Worcester.

In Illinois: Chicago, Dunleith.

In Maine: Gardiner.

In Michigan: Battle Creek, Detroit, Grand Rapids.

In Missouri: Saint Louis.

In New Hampshire: Concord, Lebanon, Manchester, Nashua.

In New Jersey: Newark, Smithville.

In New York: Buffalo, New York, Rochester, Syracuse, Yonkers.

In Ohio: Alliance, Cincinnati, Cleveland, Dayton, Defiance, Hamilton, Salem.

In Pennsylvania: Erie, Montgomery, Montrose, Philadelphia, Williamsport.

In Rhode Island: Pawtucket, Providence.

In Vermont: Windsor.

With regard to the illustrations, they are, in a majority of cases, from photographs taken directly from the tool. In many cases they are reproduced from cuts which were themselves from photographs. In a few instances the older types are shown, that comparisons may be instituted with the newer designs. There are but few illustrations of unique tools. Nearly all may be considered to exhibit types either of classes or of particular modifications under those classes. It is thought that their number adds particular interest and value to the report.

It is, of course, unavoidable that this report should not contain what is the very latest type of practice at the date of its publication. Invention and industry are so active that improvements are in the market on tools discussed in the first pages before the last pages are penned. It could only be attempted to bring the facts down to the close of the year 1880, and to leave them there. Nor should it be forgotten in these days of specialization of knowledge, how easy it is for any one fact or group of facts to escape the notice of an individual geographically distant from the center whence they proceed or where they are well known. Allowance must be claimed for shortcomings in this regard also. With these words of explanation, I place the report in your hands.

Yours, respectfully,

F. R. HUTTON,
Special Agent, Tenth Census.

PART I.

MACHINE-TOOLS.

PART II.

WOOD-WORKING MACHINERY.

INTRODUCTORY.

It is proposed in this report to review those shop-tools which have become essentials in engineering establishments, such as machine-shops, car-shops, and the like. The purely metallurgical machinery will therefore be excluded, as also the log-sawing machinery and those special machines which are adapted for but one service and the manufacture of one article.

Shop-tools are to supplement and to replace hand-labor. They have two functions. The first and most general is the conversion of metal and of wood into the special forms required for industrial uses. The second function is the performance upon the shaped pieces of the various operations necessary for finishing and fitting. The differences in structure of wood and of the metals are very great, both mechanically and economically, and give rise to very different forms of tools. It will be necessary to take up the two classes separately. The machines for working in metals are known as machinists' tools, or machine-tools. Machines for converting lumber are called wood-working machinery.

The machines for shaping and fitting metals may act by—

A.—Compressing.
B.—Shearing.
C.—Paring.
D.—Milling.
E.—Abrading, or grinding.

The wood-working tools act by—

F.—Scission, or cutting off the fibers.
G.—Paring, or shaving the surface.
H.—Combinations of these two.
I.—By abrading or grinding.

This classification takes account of the precedence of conversion of the material to the fitting operations. This arrangement will be followed in the succeeding discussions.

PART I.—MACHINE-TOOLS.

A.—TOOLS ACTING BY COMPRESSION.

§ 1.

To the class of tools acting by compression belong—

Squeezers for puddled balls.
Roll-trains.
Hammers.
Riveters.
Die-forging presses.
Bending-rolls, straightening- and bending-presses, and assembling-presses.

The squeezers and roll-trains belong to the metallurgical stage of the manufacture of the metal, previous to its delivery to the engineering establishment in merchant form. By the plan of the review, these do not come up for discussion. The first great class will therefore be the division of Hammers.

HAMMERS.

The mechanical hammers act upon the softened metal to change its shape to that desired. They may be driven from the shafting of the shop through belting, or else directly by the steam of the boiler. The first class may be called "power hammers" and may be subdivided into—

Cam-hammers—trip, tilt.
Crank-hammers.
Friction- or drop-hammers.

§ 2.

CAM-HAMMERS.

This type of hammer in its various forms is historically the earliest. Its construction was no doubt suggested by that of the ordinary hand-hammer. In one of its forms (Figs. 1 *a* and 1 *b*) a long helve of wood with a steel head is pivoted at a point behind the center of its length, and the projecting tail is depressed by wipers upon a cam at the back of all. The rise of the head is stopped by a transverse stringer of wood just after the tail of the helve is released from the wiper, and the elasticity of the helve increases the intensity of the blow. Otherwise it could be no greater than that due to the weight of the head. A greater number of blows can also be made per minute, since gravity is assisted in the arrest of the rise and by the downward impulse upon the delivery of the blow. A second form of this type has the cam-shaft between the head and the center of motion (Figs. 2 *a* and 2 *b*). The wipers bear upon a lifter, and the tail of the hammer strikes upon a wooden spring at the rear, causing the rebound. This arrangement has the advantage over the other of lowering the supports of the cam-shaft, and of

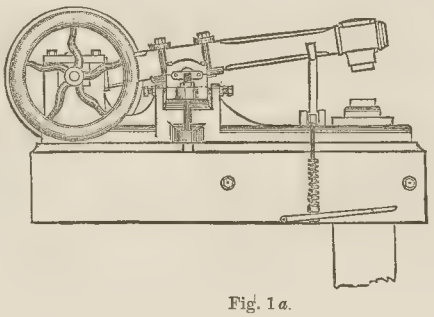


Fig. 1 *a*.

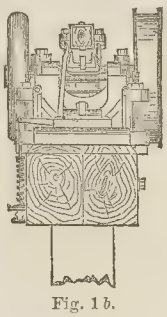


Fig. 1 *b*.

lengthening the helve segment from anvil to husk without increasing the floor space required. This latter form is, therefore, predominant in the newer types. The hammer is driven by a belt running loose upon a flanged pulley on the wiper-shaft, and engaged by a tightener-pulley pressed against the belt by a foot-treadle which surrounds the anvil. There is also a fly-wheel on the cam-shaft to equalize the variable strain upon it by serving as a reservoir of living force. By varying the tension of the driving-belt, the operator can vary the speed, and hence the intensity of the blows. When the belt slips somewhat the wooden spring is less compressed. There are usually several wipers in the cam-wheel, so that several blows are struck in each revolution. The acting surfaces are of steel let into a holder of cast iron and secured by keys, or else dovetailed. The lip on the tail or at the belly of the helve is also of steel, clamped in place by bolts. These bolts pass through ears in a cap, which overhangs the edges of the helve, so that the bolts do not pass through the wood, but outside of it. The trunnions may be secured to the helve in the same way. The head of the hammer has often been similarly secured, but the shocks and vibrations at this point have been found to crystallize bolts made of the most fibrous iron. Newer practice makes the head and trunnion forging in a ring-form. The helve passes through them and they are secured by wedges. This form absorbs its own vibrations, as they are nowhere suddenly arrested. The lower part of the head is fitted with a dovetail groove, in which the flat face or the various swages may be keyed. The anvil-block, with the face or swage similarly keyed, rests upon a post, either driven into the ground or resting upon the timber foundation of the machine. The pivots for the trunnions are made adjustable longitudinally by set-screws and jam-nuts, so as to bring the dies into any desired lateral relation. The foundation is made of a crib-work of timbers bolted together, but yielding sufficiently to take up the shocks imparted to them. The flexible and elastic belt prevents the shocks upon the cams from being carried entirely to the line shafting. Sufficient strain is thus transmitted, however, to necessitate heavier designs than are adapted for steady transmissions.

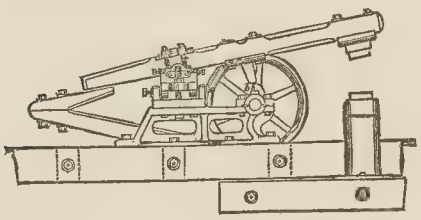


Fig. 2*a*.

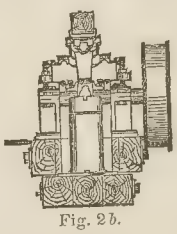


Fig. 2*b*.

For small work in gun-shops a form of "pony" trip-hammer has been successfully used. The helve and husk and bed-plate are of iron, and the cam-wheel, 10 inches in diameter, makes from 150 to 200 revolutions per minute. There are six cams on the wheel, inserted and held in place by pins. The rapidity of their blows adapts them for small work which is liable to cool rapidly.

It will be at once seen that certain difficulties surround the use of the trip-hammer or any of the pivoted hammers of the cam-disengagement class. The first one is that the face of the hammer will only be parallel to the anvil in one position of the helve. As the helve rotates about a center, a true or parallel blow will be struck only upon a piece of a certain thickness. This is no disadvantage in drawing down, or in taper work, or in work which can be treated across the face of the anvil. But this peculiarity diminishes the adaptability of the hammer for differing classes of work, and it grows worse as the helve is shorter. It can be avoided by raising and lowering the center of motion, but this adjustment can only be limited in amount, on account of the relation between the wipers and the bearing-plate.

Secondly, the limited arc of its motion restricts the applicability of the trip-hammer for deep work or for upsetting. It cannot be made to strike a heavy blow on a large piece, because the weight can fall through but a short distance. But the larger the piece the farther must the effect of the blow penetrate to perfect the welds in the interior, and hence the heavier should the blow be.

Thirdly, the shocks and vibrations of the frame-work and transmissive machinery are a drawback, especially where a large number are driven from one line.

Fourthly, the limits of variation in the intensity of the blows are narrow. A certain minimum cannot be exceeded, which is represented by the weight of the head multiplied by its fall. The maximum intensity is due to this weight together with the impulse due to the rebound. A much wider range is desirable between the first shaping blows and those which should be used to finish the shaped surfaces. But there are certain marked advantages possessed by the trip-hammer. It is cheap in first cost and in foundations. It is adapted for drawing down. Light blows can be delivered with great rapidity. But its special application is found in swage-work between formers. It will hold its own swages on face and anvil, and they can easily be of different diameters and serve as stop-gauges for each other. Hence these hammers will be extensively used for this class of work, and invention and improvement have been in the line of avoiding some of the drawbacks other than those due to the fixed center.

A type of these improvements will be illustrated by Fig. 3. Here, as before, the power is communicated from the line shafting by a belt which may be tightened by a pulley controlled by the treadle which surrounds the anvil. The driving-shaft is, however, no longer a cam-shaft, but carries an eccentric. From the strap of this eccentric a link passes up to an "oscillator," whose center of motion is the fulcrum of the helve. The eccentric is made in two parts. On the shaft is the forged iron eccentric proper, which has a flange upon one side of it. Upon

this eccentric fits a composition eccentric-ring, being secured to the first by tee-bolts, which fit in a slot in the flange. The steel eccentric-strap fits upon the composition ring. It will be seen that by this arrangement the total eccentricity or throw of the oscillator may be varied at will from the sum of the eccentricities of the

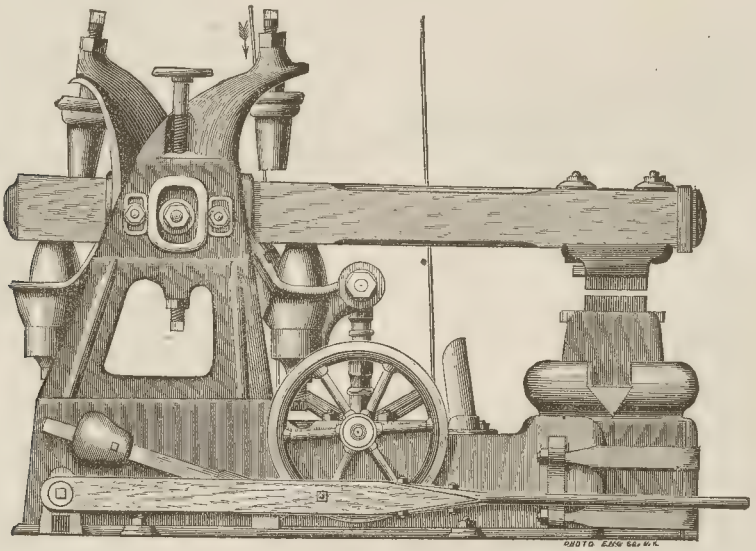


Fig. 3.

two parts to their difference. Hence an adjustable throw is obtained. The link from the eccentric-strap is fitted with a right-and-left sleeve and jam-nuts, so that the height of the hammer may be varied. Between the strap and the oscillator is a double-hinge joint, the pins being at right angles to each other in parallel planes. This prevents any untruth in the dies from making the eccentric-strap heat, because obliged to work out of line. The oscillator transmits its motion to the helve by means of two rubber cushions which are compressed against its under side, and thus alternately lift and force the head. There are two adjustable stationary cushions, secured to the husk above the helve, which arrest the rise and help to start the rise, respectively, without shock to the shaft. The helve is pivoted upon steel pins with jam-nuts, taking into taper steel bushings forced into the trunnion-castings. The pins can be separately raised and lowered by screws in the housings, and by a lateral adjustment the face of the hammer can be brought to coincide with either side of the anvil. The face is bolted to the helve by Norway iron bolts, with leather washers under the nuts to absorb the vibrations. The trunnion-castings are similarly secured. A weighted brake upon the balance-wheel arrests the motion of the shaft when the treadle is released, and the form of the oscillator is such that the hammer will not stop with the dies together. The anvil-block is separate from the bed-plate, being clamped to the front for steadiness only.

It follows from the manner of moving the helve by contact on both sides of its center, and from the use of the rubber cushions, that this hammer can be driven faster than the old style of cam-hammers, of the same size and weight. The cushioned hammers may make blows as rapidly as two hundred per minute, and with an intensity sufficient to heat a small rod to redness. This is admirably suited to keep up a low heat in small steel forging. The separate adjustments of the trunnion-pivots enables any relation of parallelism to exist between the anvil and the face without lining up the dies. The shaft is borne upon the frame and cannot get out of line, the adjustment for different thickness of die being effected by the right-and-left sleeve.

A somewhat similar design, making a specialty of the adjustment for dies of different thickness, is shown by Fig. 4. The trunnions are borne upon large gibbed slides which can be raised and lowered together by the bevel-gear and hand-wheel. As before, the helve is not positively connected to the driving-shaft, but lies between rubber cushions in the oscillating V-frame. This frame oscillates around the center of motion of the helve. It is driven by an adjustable eccentric from a shaft which carries the usual fly-wheel and flanged pulley. The loose belt is tightened by the foot-treadle, and the release of the latter applies a brake to arrest the motion. The link is adjustable in length to vary the angle between the anvil and the hammer-face. The shaft is bracketed out from the gibbed slides so as to rise and fall with the trunnions, the slack of the driving-belt being taken up by the tightener.

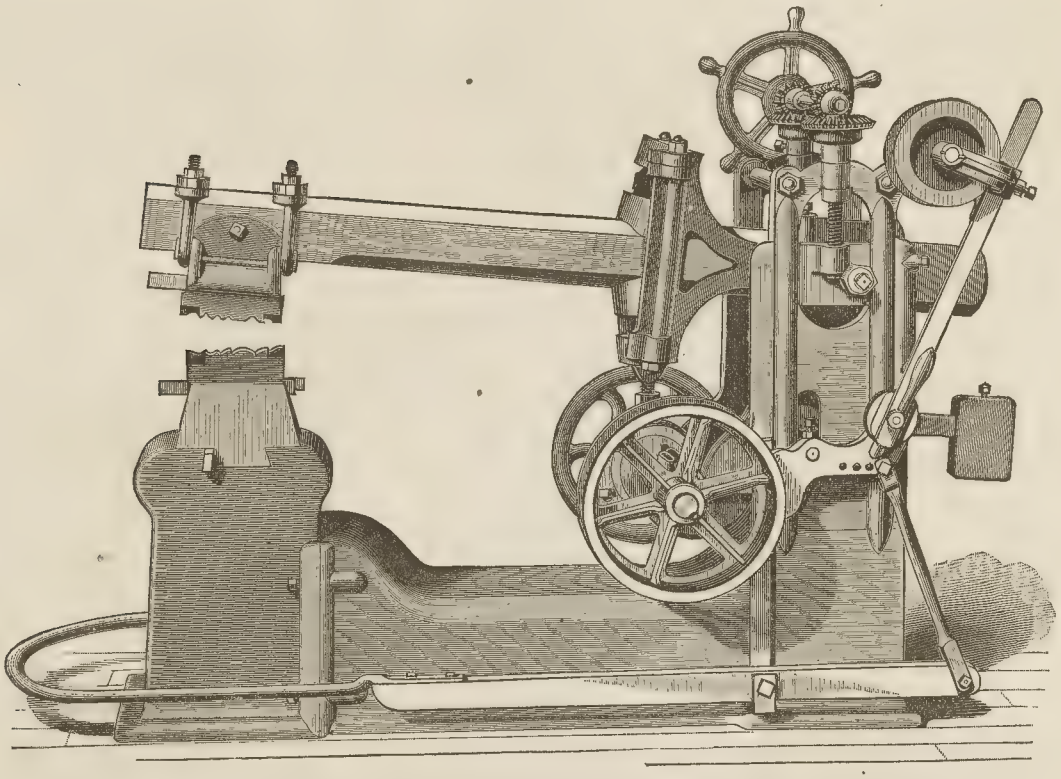


Fig. 4.

It will be seen that in this hammer the adjustment for dies and work of different thicknesses is very easy and rapid, but that considerable shock must be borne by the eccentric-shaft. The use of rubber cushions enables the blows to be delivered quite rapidly.

§ 3.

CRANK-HAMMERS.

The object sought in the design of these hammers is the delivery of a dead-stroke, while the faces of hammer and anvil shall remain parallel for all thicknesses of work. The crank is used to produce the reciprocating motion of the head, either directly or indirectly, and the oscillating helve disappears. It is of course impossible to connect the head directly to the crank-pin. The blow could not then be a dead one, penetrating into the inner particles of the work, but would be an elastic one, affecting the surface only and in part. Moreover, different thicknesses could not be operated on without inconvenient readjustments. It will therefore be found that between the crank-pin and the head there will be interposed springs of some sort. Their effect will be to cause some free motion and to increase the range of the tool and also the force of its blows. The crank is well adapted for this class of motion, inasmuch as it begins the motion of the head by a gradual lift, increasing until half stroke is reached, when the lifting effort slowly diminishes, permitting the inertia of the rising head to slacken the strain on the springs as the crank reverses. On the down-stroke the accelerating crank compresses the spring upon the moving head, giving this extra force to its fall.

One of the hammers of this type is shown by Fig. 5. It is driven by a belt, which may be engaged with the crank-shaft either by a clutch or by a tightener upon the belt running loose. The crank-pin is often made to bolt into a slot in the balanced wrist-plate, so that the stroke of the head may be varied. The head slides between guides on the front, so that it shall always strike a fair blow on the anvil beneath. The connecting-rod, made adjustable in length, carries at its end a clamp for a steel locomotive-spring, whose ends are drawn together by a multiple band of flat leather. The head is hung from the middle of the leather link. It will be seen how the living force of the head will compress the springs on the up-stroke, that compression being given out in the blow. The amount of this compression is controllable by the will of the operator, since it depends entirely upon the speed of

the shaft. The more rapid the rise of the head the greater is the efficiency of the spring. The speed, being controlled by the frictional contact of clutch or tightened belt, is varied by greater or less pressure upon the foot-treadle. The anvil is made a part of the frame, which is left open at the back to permit drawing down across the anvil. Very often the faces of the anvil and head are made T-shaped, so as to act equally well whether work is presented from front or side. Here, again, the interposition of the elastic media permits a large number of blows to be made per minute. The 100-pound hammer, suitable for general forging and die-work, may make from 200 to 250 blows per minute.

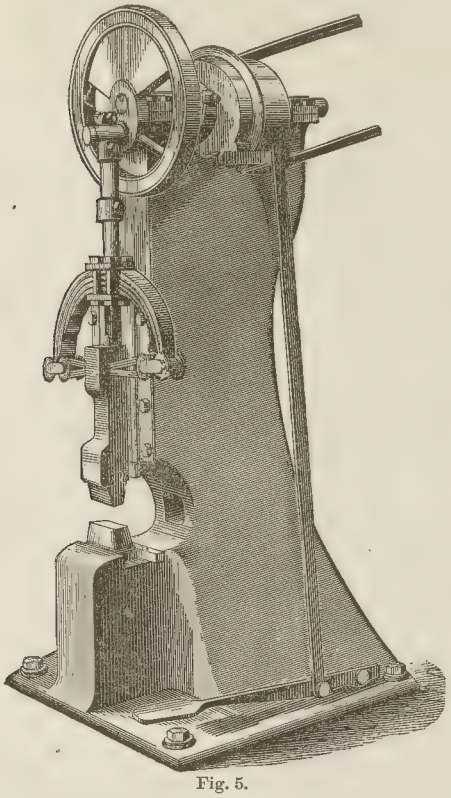


Fig. 5.

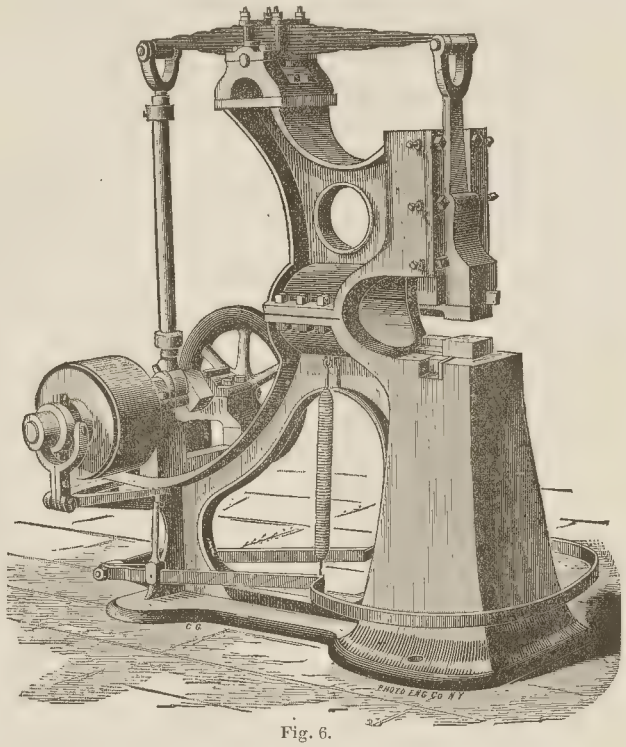


Fig. 6.

A design involving similar principles is illustrated by Fig. 6. Here the crank-shaft, with its friction-clutch, is put lower and nearer the holding-down bolts, and an adjustable connecting-rod causes a spring working-beam to lift and lower the head. The slides are gibbed, and the frame at the rear is made open. It has the same adaptability to machine forging where the depth of the work is being continually varied, and strikes a more or less dead blow.

It were a very natural step to replace the elasticity of a steel spring by the elasticity of a cushion of air and apply it to produce dead blows with a crank-hammer. Such an arrangement is illustrated by Fig. 7. The upper part of the hammer-head is made into a cylinder, truly bored, in which fits a piston, connected by a rod and pitman to the crank-pin. When the pin rises the piston rarefies the air below it, and compresses the air above it. The piston in its rise has uncovered several small ports in the bore of the cylinder, through which air enters below it. The compression of the air has been sufficient between the piston and the top of the cylinder to lift the whole cylinder and head, and the living force of the motion upward will continue after the pin has begun to come down. Hence by compression of the air below the piston will result an increased velocity of fall and greater force of blow than are due to the weight alone. The connection also not being positive, the blow will be a dead one. The crank-shaft, as usual, is driven by a loose belt, engaged by a tightener controllable by the foot. Nearly all have also a brake to arrest the motion quickly. In another design this arrangement is reversed, and the connecting-rod moves the cylinder, while the piston is connected to the head of the hammer.

Another type of crank-forging machinery is shown by Fig. 8. The head is guided between the two uprights, which oblige it to fall so as to strike a fair and dead blow. There is no reinforcement of the weight of the head. The head is lifted by a flat leather belt, which is attached to a pin upon the crank overhead and is a little too long.

The belt is attached to the rotating pin by being clamped to a composition sleeve, S, which takes the wear. As will be seen from Fig. 9, the crank is revolved by the gearing from the belt-wheels, through the ratchet-wheel A and dog *d*. When the drop is up, the crank stands a little forward of its upper dead-center, and is prevented from falling by an arm which strikes against the ratchet-arm R. When this arm is pulled away by pressure upon the treadle below, the drop falls, the dog sliding past the ratchet-teeth, since it moves faster than the latter, and is prevented from clicking by a guard. When the blow is delivered and the ratchet-arm stands up, the dog falls into the ratchet-wheel, and the gear takes hold to lift the drop. The dog stays in gear till the rotation of the arm is stopped as before, or until the weight of the drop pulls the dog out if the treadle is kept down. The lifter-gear is carefully cushioned with rubber disks to absorb shocks, as also are the detents and stops.

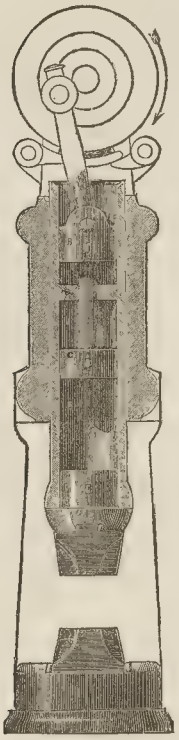


Fig. 7.

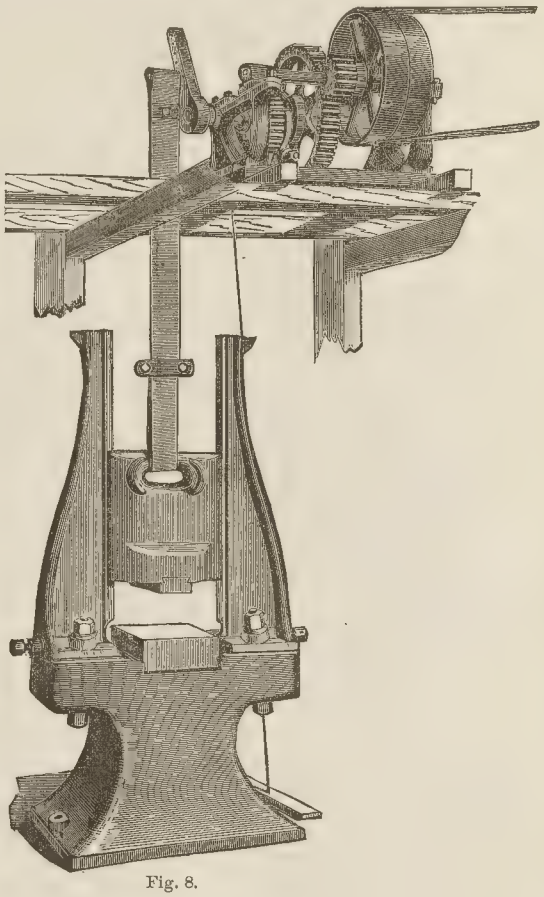


Fig. 8.

This device is admirably adapted for die-forging, and is better for that than for the miscellaneous work of a general forge. It can deliver only from sixty to eighty blows per minute, although they can be heavy and sufficient. It has the advantage of avoiding the necessity of attaching the lifting-gear to the guides, and any settling of the anvil is less annoying or disastrous than in some of the other designs. The flexible yet maintained connection between the drop and the lifting-gear gives an inelastic blow and yet prevents a false blow being given, due to the rebound after the fall of the weight. The length of the lifter-crank is made alterable for different heights of fall, and the uprights are held from spreading by inclining inward the faces of the wings and putting in the holding-down bolts normal to these faces. Lateral adjustment is secured by the set-screws and jam-nuts.

This arrangement has been especially applied for die-forging, when the machine will be called a "drop-press". The process of "drop-forging" depends upon the principle of the flow of metals under strain. A pair of dies is used, each containing one-half of the desired volume. One is secured to the anvil-casting and the other to the face of the drop, so that they shall match when together. The upper die is usually keyed into a dovetail groove in the face of the drop, and the lower one is made to match it by the adjustment of four or six poppet-head screws by

which the die is held. The dies are of refined steel, the form to be produced being milled out on a jigging-machine before the steel is hardened and annealed. When in use, red hot-metal in merchant form is put in the lower die so as not quite to fill it. The upper die is released, to fall and force the metal to fill out the interstices of the dies, both upper and lower, of which of course the reproduction is complete. Wrought iron or ingot steel or cast steel can be treated in this way, and quite complicated forms can be very cheaply, because rapidly, produced. The small carriage hardware, gun, pistol, and sewing-machine forgings, and small tools, such as wrenches and the like, are now made in this way, with an enormous increase in the productiveness of a given establishment and a given gang of men. But one blow is usually necessary to complete the forging, and more are unwise, inasmuch as a "fin" of the superfluous metal is forced into the space between the dies, which thin fin cools rapidly. Any extra blows are borne by this fin and will only deteriorate the dies. This fin being removed by putting the shaped piece between "trimming-dies" in a punching-press, any openings will be punched out, and the finished piece will be sheared off from the bar of which it is a part. Slight treatment with emery-wheels or by heavy pressure in a cold-press will be all that is required to produce a finished article. It will be seen that the crank-lifter is very well adapted for this class of work.

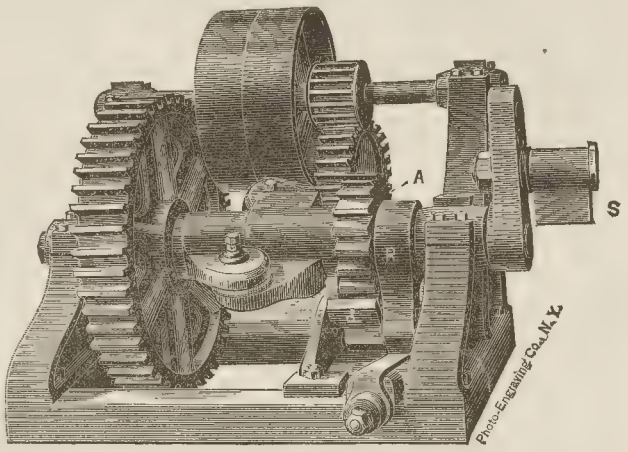


Fig. 9.

§ 4.

FRICTION- OR DROP-HAMMERS.

These hammers have received their special development to meet the requirements of drop-forging. They are adapted to give a small number of blows per minute, by a weight falling through a considerable distance.

The early germ of these hammers is, no doubt, in the old "monkey" hammers. A piece of flat belt-leather passes from the head of the drop over a revolving shaft and down to a weighted handle. The weight of the handle is not sufficient to make the belt seize the shaft, but when the handle is pulled by the forger the normal pressure is sufficient to cause the power to lift the drop. When the handle is released the blow is given. The drop is guided so as to give a true blow.

Hammers somewhat similar are still in use, and successfully. An overhead roller winds up the flat belt when a clutch is engaged. The weight falls when the clutch is released. To prevent shock, the leather is much too long, and a small counterpoise weight on a cord from the roller secures that the belt shall always be rightly wound upon the roller.

If the belt of the early form be replaced by a flat board which can be gripped between two overhead rollers revolving in opposite ways, and which can be released at will, the foundation for the modern friction- or roll-drop hammer is laid. The differences in the different forms will be more in detail than in principle.

In the hammer of Figs. 10 *a* and 10 *b* the two rolls are of cast iron finished smooth and driven in opposite ways by the belt-wheels, which carry one an open and the other a crossed belt. One roll revolves in fixed bearings. The other roll turns in a bearing at each end, which is a cylindrical bushing in the journal-box, the roll-bearing being out of the center of the bushing. It will be seen that if the bushings be revolved through a small angle, the axis of the roll will be displaced laterally, so that the board between the rolls can be released or seized with any desired pressure. The bearings of the fixed roll are made adjustable to compensate for different thicknesses of board and for wear, and to keep the board always vertical. The movable roll is released from the board by the rise of a rod, D, which is connected with loose joints to the foot-treadle, so that the weight of the rod acts to keep the rolls together. Upon the rod D is a chock, which, when struck by the drop in its rise, will lift the rod and release the board, while at the same instant the bent lever-latch on the other side of the head drops in place to keep it from falling. The head therefore remains in place until the treadle is depressed; when the latch is withdrawn the rolls are kept apart, and the head falls. The latch is adjustable on the guides to vary the fall by steps of 6 inches, and the treadle and latch are kept up by a spiral spring or by a weight. The lifter-rod D is made to connect to the

treadle by contact-joints so that the rising of the chock need not jar the treadle. A turn-buckle is put in this linkage so as to adjust the relation between the treadle and the rod D without interfering with the latch on the other side, and to permit a rapid series of blows with uniform force without full motion of the treadle.

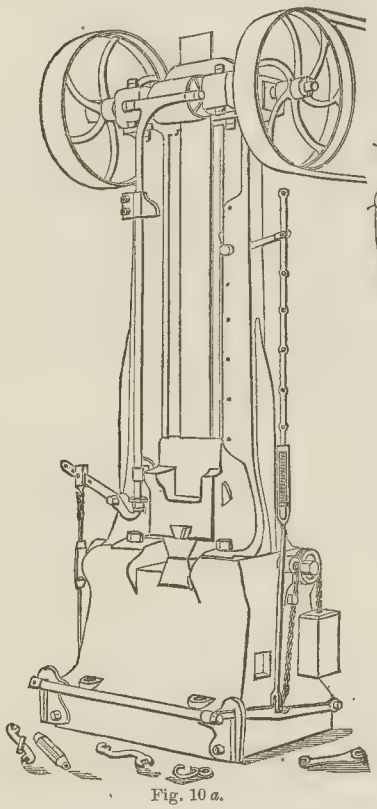


Fig. 10 *a*.

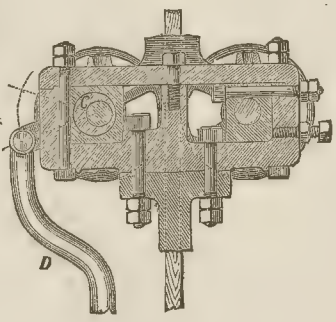


Fig. 10 *b*.

The next type of hammer has the two rolls geared at each end, one only being driven by one or two belt-pulleys (Fig. 11). The teeth are of involute profile so as to work equally well at different center distances. The movable roll is hung in bearings on a swinging yoke, which is pulled over by a crank-lever acting upon a cam, the lifting-rod being moved from the treadle as before. There is the similar latch-gear on the right-hand side, automatic and adjustable. An automatic trip-gear may be added if a series of uniform blows should ever be called for.

The hammer of Fig. 12 has the two rolls geared together and brought together by eccentric mounting, as before. The contact is maintained by the weight of the lifting-rod D (Fig. 13), reinforced by a spiral spring. As the hammer rises it strikes a dog on the rod, opening the rolls and releasing the board. Since the lifting-rod is not attached to the treadle, as in the former designs, the release of the dog as the hammer falls would close the rolls and stop the fall. To prevent this a switch springs in under the end of the rod, holding it up and keeping the rolls apart. The head has a curved plane on it, which forces out the switch from under the rod when the blow has been delivered, lowering the rod and causing the rolls to lift again. This switch is pivoted upon an eccentric mounting to take account of varying thickness of die or work. The dog-rod can also be worked by hand-lever at side of frame or by a small treadle. The foot-treadle operates a lever overhead attached to a pair of toggle-levers which grip the board on its descent except when held away by the depression of the treadle. If the treadle be held down a number of uniform blows will be struck, which especially adapts this arrangement for certain classes of work. For miscellaneous work and blows of varying intensity the adjustment of the other types gives the operator more freedom in the use of his hands. The toggle-joints are upon eccentric bearings, which let the board slip through them on the up-stroke (Fig. 13), but which hold it when its motion reverses. All such friction contact bearings are made adjustable to compensate for wear and variations in thickness.

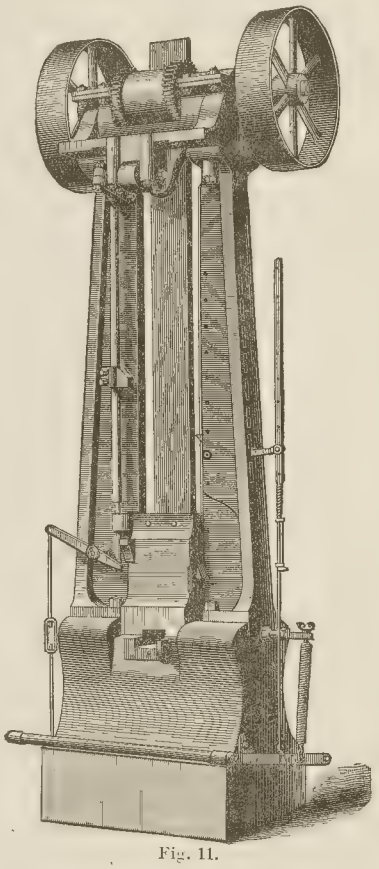


Fig. 11.

All the hammers of this friction-roll type are open to the objection that the rolls when brought together demand that the drop shall start from rest and acquire at once the full speed of its lift. There must therefore be a slip somewhere while the inertia of the head is being overcome. If this slip occurs in the driving-belts they will wear or burn. If it occurs between the board and the rolls the former will become worn into a hollow at the point of first seizure and the rolls will fail to grip at that point. But the board of white oak or hickory is as apt to deteriorate from other causes, and the general adoption of this class of hammer for drop-forging is proof of the satisfaction it has given in that class of work. They do work which could only be done otherwise by heavy steam-hammers, which would involve

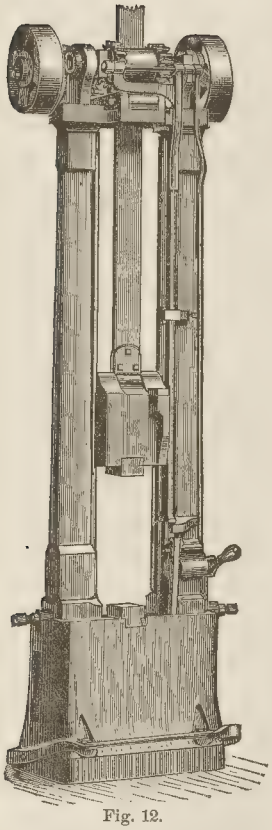


Fig. 12.

great outlay and expensive accessories and give but a limited production. A battery of these hammers can be set up in one establishment and its capacity can become almost unlimited. Ordinary labor can handle them, and but one man is required. In one of the shops for fire-arm manufacture a special type of drop-hammer is in use. A square central pillar has pawls on its four faces and is made to reciprocate vertically. Four guided drops are lifted by each rise and are held from falling by pawls. The release of the pawl of any head, at the will of the operator, permits the head to fall. The heads weigh 500 to 800 pounds, and may fall 30 feet.

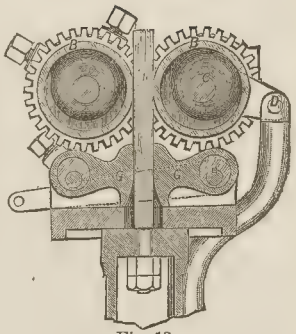


Fig. 13.

§ 5.

STEAM-HAMMERS.

In this class of hammers the power of the steam from the boiler is applied directly instead of indirectly through the engine and shafting of the shop. They form, therefore, a class distinct from the power-hammers previously discussed.

The hammers of the pivoted type directly driven by steam present themselves first. In these the large wooden helve is pivoted upon trunnions, and just in front of the husk is put a steam-cylinder of large diameter and short stroke, below the floor level (Fig. 14). This cylinder is usually single acting, lifting the helve, and letting it fall by its own weight. The rise is arrested by a wooden spring buffer beam at the tail of the helve. The valve admitting steam to the cylinder is a plain slide-valve, worked from the cross-head, or is in the form shown in the cut, a rotary sliding valve. In the form shown in the cut, the rotating valve is balanced by being hung by a brass ring and bolt from a plate of flexible copper or steel in the bonnet of calculated area sufficient to keep the valve from bearing too hard upon the seat with the given working pressure. In the older forms, worked by an arm from the cross-head which struck tappets upon the valve-stem, the difficulty was due to the shocks against the tappets. The valve-stem had a stout thread cut on it, and these two tappets could be separated or brought together for work of different thickness and for different heights of fall. But as the slide-valve was unbalanced, it took considerable power to move it, and the cross-head arms and the valve-stems were continually breaking and becoming battered. Other arrangements for admitting steam were by the use of a cock-valve, which was revolved upon its axis by the cross-head arm which struck tappets having inclined faces, and displaced them around their axis. And again the cross-head arm acted upon two inclined planes in slots in a plate, the planes being adjustable in position at the will of the operator. In the form shown, while the adjustable tappet hand-nuts are retained, yet the valve moves so easily that the gear is not worn out. The valve-seat is near the bottom of the cylinder, permitting the use of a short steam-passage, with long narrow port, and giving a decisive sharp blow. The position of the port for exhausting also enables the condensed water to drain out easily and quickly, and lets the hammer fall easily upon the work. The speed at which the hammer may be driven adapts it for several classes of forging, and it can be applied for billeting and faggoting. In one case where so applied the helve is a box girder of ingot-steel plate. It has the advantages for swage- and die-work possessed by every helve hammer, but also has their limitations.

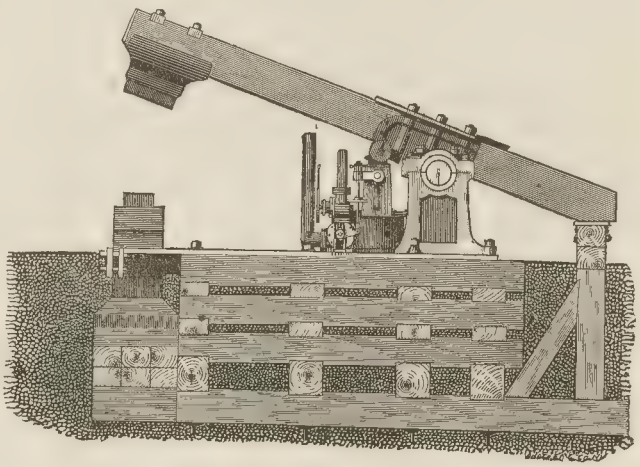


Fig. 14.

To a similar type belongs the steam-striker in limited use in forges. A steam-cylinder of short stroke has its rod connected to the short arm of a rock-shaft. At right angles to this arm is a second arm much longer, on whose

end is the hammer-head. A small motion of the short arm, caused by admitting steam into the cylinder, brings the head down with high velocity upon the work between itself and the anvil. The rock-shaft bearings are so adjustable, relative to the cylinder, as to enable the plane of the sledge-stroke to be carried round through 180°.

The direct-acting steam-hammer consists essentially of a vertical steam-cylinder, in which plays the piston actuated by the steam. Upon the end of the piston-rod is the hammer-head, which strikes the work as it rests on the anvil below. The head may either be lifted by the steam and allowed to fall by its own weight, or extra force may be given to the blow by admitting steam above the piston-head. The cylinder will be carried and the head will be guided by the frame, and the admission and exhaust of the steam will be controlled by suitable valve-gearing.

This type of hammer has very marked advantages. Such are the simplicity of its mechanism, the elastic connection between the head and the driving power, and between the head and the frame; the absolute controllability of the blows, in frequency, in power, and in height; the saving of expense of power when the hammer is not in use, and the avoidance of useless wear of belts; and lastly, the economy which results from putting the hammers where they are wanted, without regard to the conditions imposed by transmissive machinery. There may be a small loss from condensation in the steam-pipe, but careful lagging will reduce this to a minimum. Then, further, the direct-acting steam-hammers are adaptable to all classes of work. Plain forging, die-forging, drop-work, upsetting, etc., can all be done upon the one tool without necessitating any change, except in the dies. The work can be presented in any direction, the space around the anvil being open on nine-tenths of the circumference. A number of swages can not be held at once, as in helve-hammers, lest the blows be delivered out of the axial line of the rod.

Steam-hammers are made with single or double frame, according to their weight. The lighter hammers have but one upright (Fig. 22), consisting of a curved post of round or rectangular cored section, supporting the cylinder at the top. The anvil is carried upon a separate post, which passes down through the sole-plate of the upright. The anvil and tup or head are usually put oblique to the plane of symmetry through the upright, so as to enable the smith to present his work fairly either across or along them for drawing down and finishing. The larger hammers have two uprights, giving rise to what has been called the A-frame. Two uprights are bolted to the foundation, one on each side of the anvil, of such a shape as to guide the head by their upper parts in some designs, while the cylinder is cast upon an entablature to which the uprights are bolted. In other designs the piston-rod guides the head and the uprights are of different shape, to give greater room around the anvil and between the frames. Where the shape is such as to give little room between the uprights around the anvil, the latter is either set obliquely or else the legs are spread sidewise, so as to separate each into two and to leave a passage through each. The object of these two arrangements is to enable the forger to hold chisels and fullers at right angles to the work, and to enable him to see it without deceptive foreshortening.

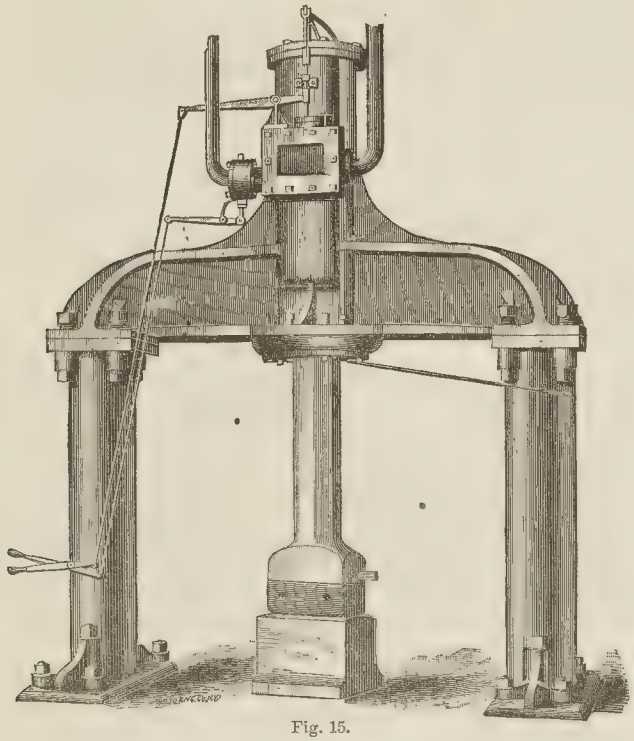


Fig. 15.

To give free room around the anvil the "high-frame" hammer has been made (Fig. 15). The frame consists of two vertical pillars surmounted by an entablature, upon which is secured the cylinder. In this the anvil is set oblique to the plane through the pillars.

The uprights of double-frame hammers are usually bolted and keyed between lugs upon a sole-plate which envelops the anvil-pier (Fig. 16). This sole-plate is bolted by long holding-down bolts to foundation piers of masonry or brick, one at each end, having considerable lateral spread at the bottom to distribute the pressure over a large surface. On marshy ground it will probably be necessary to drive down piles first and cover them with a timber crib-work, around which concrete is rammed. For the lighter hammers the piers may be of cob-work timbers, filled in with concrete. In either case the piers are surmounted with a thickness of timber, perhaps of 3-inch plank, and on this the sole-plate is bolted and trued. The anvil-pier is similarly built, with lateral spread to distribute the blows, but the three or

four courses below the anvil-plate will be of heavy timbers bolted together. Between lugs on this plate will be keyed the anvil-block, which again will receive the die in a dovetail groove in its top. In the lighter hammers the anvil may be all in one piece, and rest upon a flat pier of timber passing down through the foundation of the frames. In the single-frame hammers the arrangement will differ only in depth of foundation and in the permissible use of timber (Fig. 17). It is a very usual and excellent plan to use jam-nuts on the foundation-bolts, that they may not become loosened by the vibrations.

A primary difference in different designs of hammers arises from the methods of guiding the head. In the first designs the steam only lifted the piston and head. Hence a small rod was used, and the weight of metal for the blow was put in the head or ram. Therefore it was necessary that it should move between guides in the uprights, to avoid flexing the light rod. In the later designs of the Morison and high-frame hammer the weight for the drop was put into the rod, so that the increased section made it possible to guide the lower end from the cylinder above. This left, of course, a much higher opening around the anvil, but made it necessary to have some arrangement to prevent the rod and die from turning. In the high-frame hammer the rod is made polygonal, and plays through a polygonal stuffing-box (Fig. 18). In the Morison hammer the bar is prevented from turning by the grooves on opposite sides of its upper prolongation which work the valve.

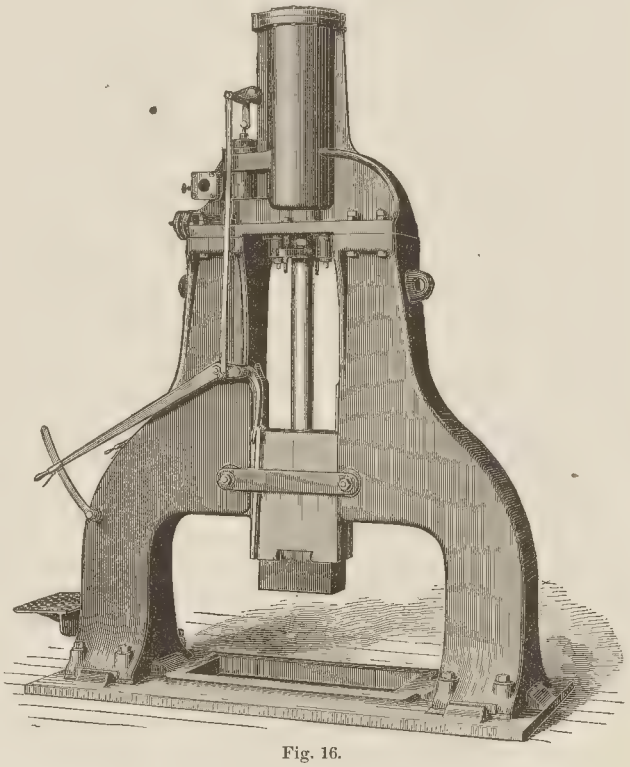
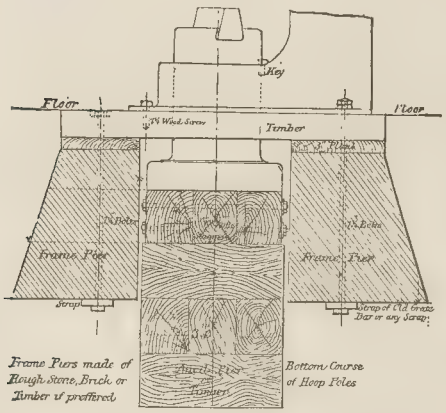


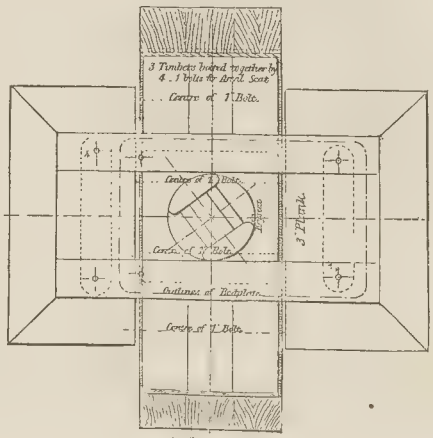
Fig. 16.

The difficulty connected with the guiding by the rod from the cylinder, is that any blows reacting upon the rod outside of its center line tend to force it to one side and cause the stuffing-boxes to leak and wear, even with the increase of bearing surface. The prevalent design of to-day will be seen to favor the other system, even with its drawbacks.

The second difference will be in the actuation of the valve which distributes steam to the cylinder. The valve motion for a steam-hammer presents certain distinctive features. It is desirable that the valve be moved automatically by the hammer, at least in the smaller forms; but the attainment of this end is beset with two difficulties. In the first place, the stroke of the piston needs to be cushioned by steam on the up-stroke, but must



SECTIONAL SIDE VIEW.



PLAN.

Fig. 17.

not be so cushioned on the down-stroke. If the blow be cushioned by steam, only part of the force of impact is received by the work. Most of it, in fact, is taken up by the steam-cushion, and the hammer loses at least 50 per cent. of its efficiency. Moreover, dead blows are more potent to change the shape and effect the welds in the interior of the piece than elastic blows. If the reaction of the particles from the blow is not resisted by the weight of the ram upon them, the effect of any blow will be confined to the surfaces only. On the up-stroke, however, there must be a steam-cushion to arrest the piston, else the upper cylinder-head will be knocked out. The valve must have steam lead for the down-stroke, but none for the up-stroke; or, in other words, the valve must open the lower port after the hammer has come to rest.* Fig. 18 shows how this steam lead is secured in hand-worked hammers. The rise of the piston strikes a stem which insures the preopening of the upper steam-port, even at the peril of the operator.

The second difficulty about automatic gear arises from the fact that the hammer is to forge pieces of varying thickness. When a piece is to be drawn down, it is much thicker when the first blows are given than it is when it is being finished. Moreover, the hammer may be called on to work a thin flat just after a job of upsetting, so that the valve-gear must act with equal ease for a long or for a short stroke at the lower or upper part of the travel of the ram. This second difficulty is overcome by having the lever to which the valve-stem is attached pivoted to a stud which is not fast to the frame of the hammer. This pivot-stud is upon the end of the short arm of a bent

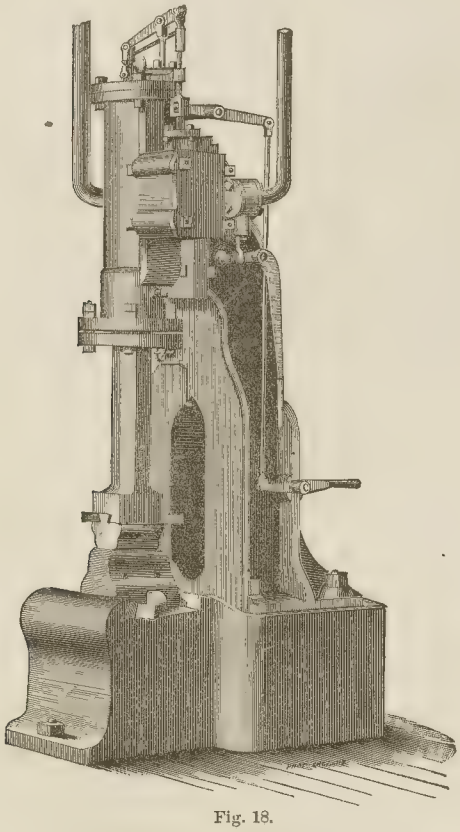


Fig. 18.

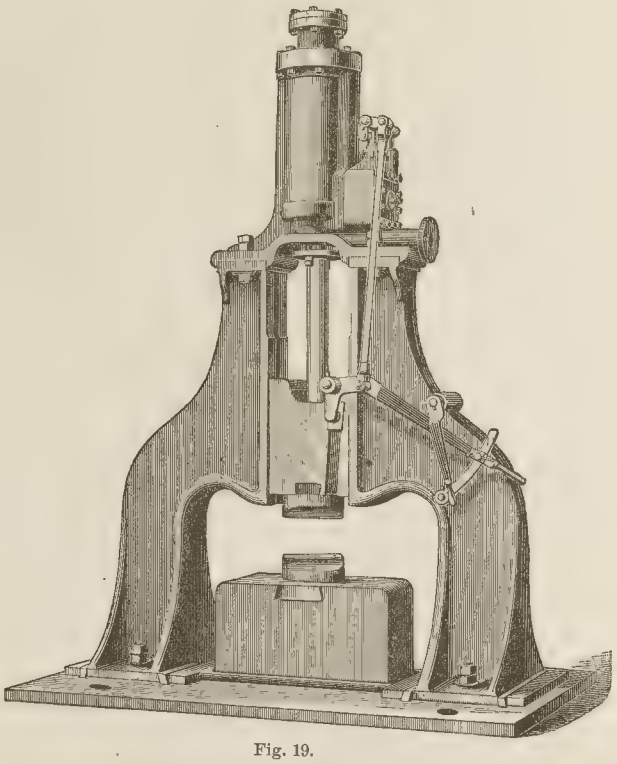


Fig. 19.

lever which turns around a fixed center. This lever is called the working-lever. The long arm ends in a handle, and can be held in any desired position, on a sector near the free end, either by a latch or by a set-screw. The stroke of the ram being so much greater than that of the valve, the arm to the valve-stem will always be shorter than that to the ram, on the floating lever, and therefore a small adjustment of the floating pivot will bring the valve into the proper relation with any part of the length of the stroke.

The overcoming of the first difficulty follows very simply after the second one is provided for. It is accomplished by means of a swinging curved wiper-bar, centered upon the short end of the working-bar in prevailing practice. A short arm at right angles to the plane of the face of the wiper is connected to the valve.

An inclined plane is formed upon one face of the head, and this wiper is held to contact with this plane by the weight of the valve acting upon the short arm of the wiper. When steam drives the hammer down it falls faster than if gravity alone acted on it. Gravity alone acts upon the valve. Hence the descending ram will get away

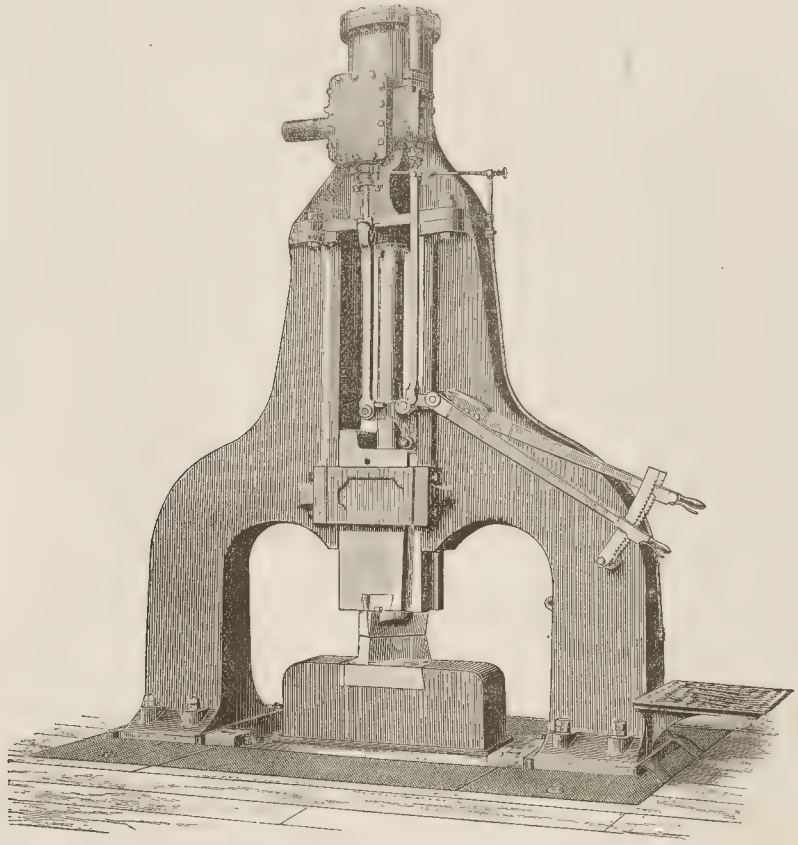


Fig. 20.

from the wiper, which will swing into contact after the hammer has stopped, and properly open the valve. A dead blow will thus be given without steam-cushion. Upon the up-stroke the head and valve move together, and steam lead may be always secured to cushion the rise, or it may be effected by exhaust compression. By handling the working-lever dead blows may be given by the ram as a drop. The working-lever must pull the wiper away, as the two contact surfaces fall at the same rate because acted on by equal forces. Of course, for this gear, the valve must be balanced so as to fall easily under steam. For rapid work the weight may be helped by a spring, or for slow work it may be retarded by artificial friction or by counterpoises.

In the Sellers hammer the connection is positive or maintained between ram and valve, but the coincident motion of the working-lever with the blow retards the admission till after the blow is delivered.

Large hammers are usually worked by hand; but inasmuch as the stroke of these larger valves requires more motion of the working-lever a compound motion is often applied. A groove in the ram moves the long arm of a bell-crank lever, whose short arm is connected to the valve-stem, and whose pivot is on the working-lever as in the previous cases (Figs. 19 and 20). Very many of the largest blooming-hammers are worked directly from the handle, independent of the ram (Fig. 27). In the Miles hammer, shown in section in Fig. 21, the valve is a hollow piston-valve, taking steam from the inner edges and exhausting at the ends and through the middle. The hollow valve permits very short passages, and the position of the exhaust-chamber causes all water of condensation to be carried away from the cylinder even without drip-cocks. The valve-rod needs no stuffing-box with its attendant friction, since it works in exhaust steam only. The piston-rod is tapered into ram and piston, and the piston is packed by steel rings. The head is guided by flat guides with a projecting lip for holding it sidewise, or in some

of the smaller sizes the head is planed with V-grooves. An adjustable gib is also used to take up lost motion and wear by inclined planes controlled by a screw. To avoid the danger from "hammering upward", buffer-springs are put below the cylinder, consisting of compound volute car-springs (Fig. 22). These react against the ram and

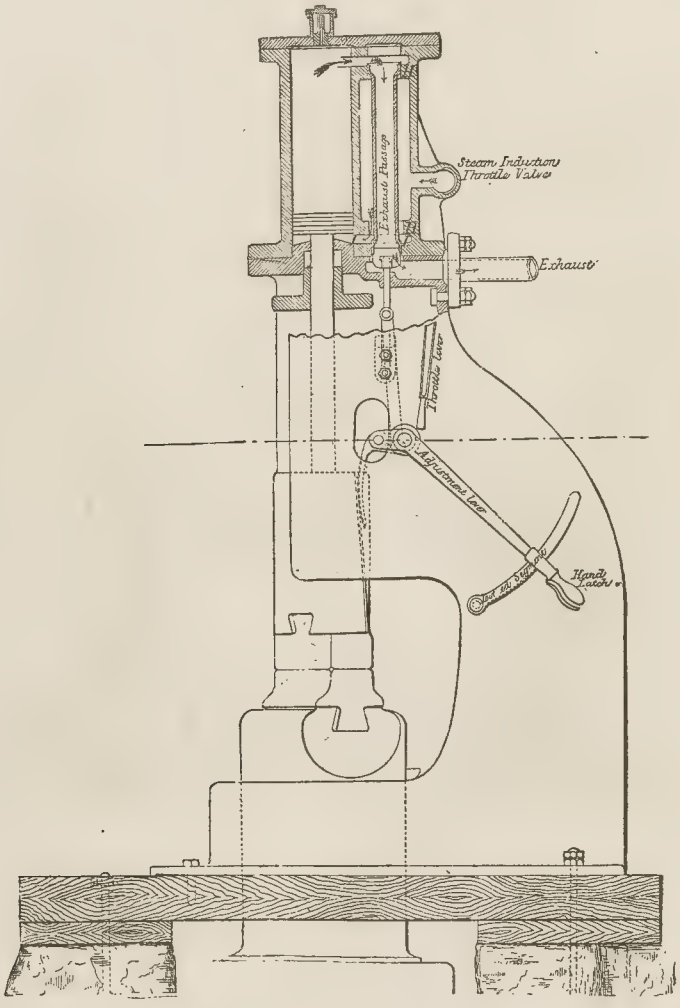


Fig. 21.

prevent injury to the upper cover. The rod is made long enough to permit the piston to protrude through the top of the cylinder when all buffers and the stuffing-box packing are removed. This allows the inspection or renewal of piston-packing without disconnecting the parts.

Fig. 16 shows the larger size, and Fig. 23 shows an especial arrangement for drop-work. The throttle-valve is connected to the dangler by a screw connection, so that the degree of force of any single blow or of any series of automatic blows can be governed by a foot-treadle and the hands of the operator be free for his work.

The throttle-valve for the hammers is the Davis sliding valve of the Corliss type, working in a jacketed casing. The pipes are connected to the hammer by expansion joints, to avoid leaky connections. The openings are arranged so to face as to permit free approach of cranes on both sides.

The Bement hammer (Fig. 24 and Fig. 20) differs in the use of a flat gridiron slide-valve, balanced by means of a shield which slides on a surface opposite to that of the valve-seat. The dangler also is made longer. The piston is cushioned to prevent overstroke by closing over the exhaust passage, which is not at the extreme top of the cylinder. In small hammers the piston and rod are made of one forging. In the larger sizes the rod is slightly tapered and headed over cold. Steel packing-rings are used.

The Morgan and Williams hammer (Fig. 25) uses a square piston-valve. The back and sides of the valve are protected from steam pressure by a hollow trough casting, with ports in the inside of the trough which match the ports in the seat, and are separated in the hollow part by partitions. Steam therefore enters the passages both through the seat-ports and also through those in the shield when opened by the valve. The valve and shield are faced off together upon their lower sides, and the valve is afterward relieved enough to slide under it when the shield is forced to the seat. It is held in place by one or more set-screws in the bonnet of the chest.

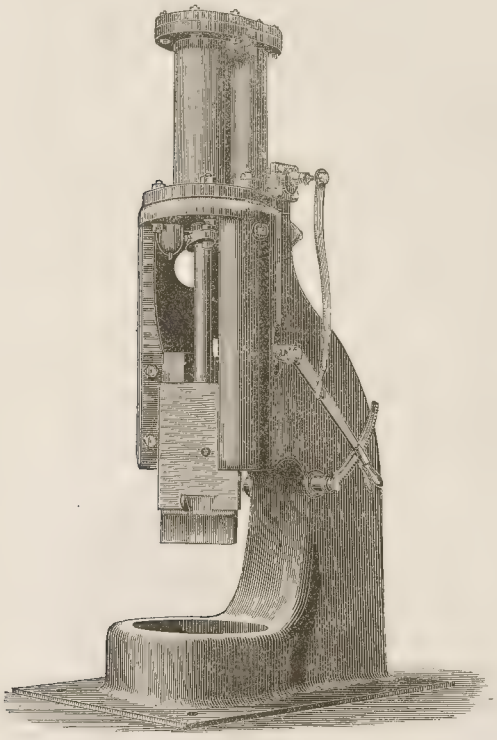


Fig. 22.

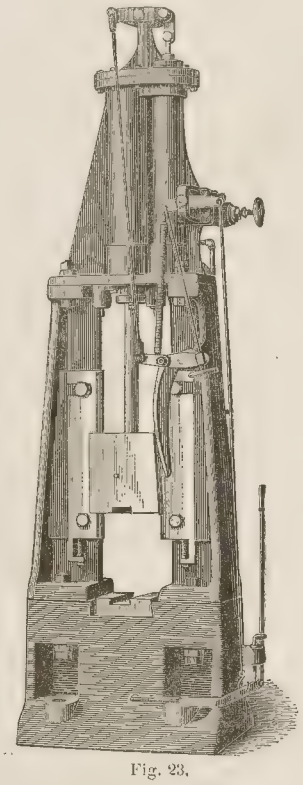


Fig. 23.

For hammers for working steel, which must be handled at high speed, two valves are used, one for steam above the piston and one for steam below, with separate throttle-valve for each chest.

To protect the upper cover of the cylinder, a small cylinder on top contains a volute buffer-spring, whose spindle takes the blow, and should breakage be unavoidable it is the small weaker cylinder which is most sure to go rather than some more expensive part. Ramsbottom's steel piston-rings are used for packing. The rod is fitted as in the Miles hammer with a simple taper fit into the ram. The shocks of impact keep this joint perfect, making it tighter at every blow. The piston is forged on the rod in small hammers. In the larger sizes it is shrunk on and headed over. In place of the dangler or wiper, the valve is moved by a square inclined groove or ridge upon the side of the ram. This controls a bell-crank connected to the valve, the crank being pivoted upon the working-lever. Their drop-hammers have an equalizing pipe on the Cornish system to prevent the necessity of admitting air to the cylinders on the descent. They can be made controllable by the foot of the operator.

In the Sellers hammer (Fig. 26) the ram, rod, and piston are in one forging. The rod is prolonged above the piston to serve to guide the end of the rod by the upper cylinder head as there is no ram guided between slides as in the previous designs. The lower part of the rod is made larger than the upper part above the piston in order that the mass of metal may be greatest near the point of impact. To this large bar is attached the hammer-head proper by means of a circular key and to the head are keyed the dies. For keying the dies a crimped key is preferred, which holds the die with elastic pressure. The key can be bent anew when loosened by use.

The valve-gear is worked by an obvious system of levers, to which motion is imparted from a brass yoke interior to the cap which protects the upper rod. This rod has two opposite diagonal grooves in it, in which fit brass keys attached to the yoke. The up-and-down motion of the rod causes transverse reciprocation of the yoke,

which motion is carried out to the valve-levers through the stuffing-box at the back. The pivot for the lever attached to the valve-stem floats from the end of the working-lever. The valve-yoke also serves to keep the hammer-bar from turning round. In addition to this ordinary gear a supplemental valve is introduced, which controls, by hand, the exhaust from the lower port, without interfering with the upper port. This enables quick, but light-cushioned blows to be struck for finishing, the operator being able to gauge their intensity by the completeness of his exhaust-cushion below the piston. The speed of rise is not affected, and the confined steam below expands upon the up-stroke.

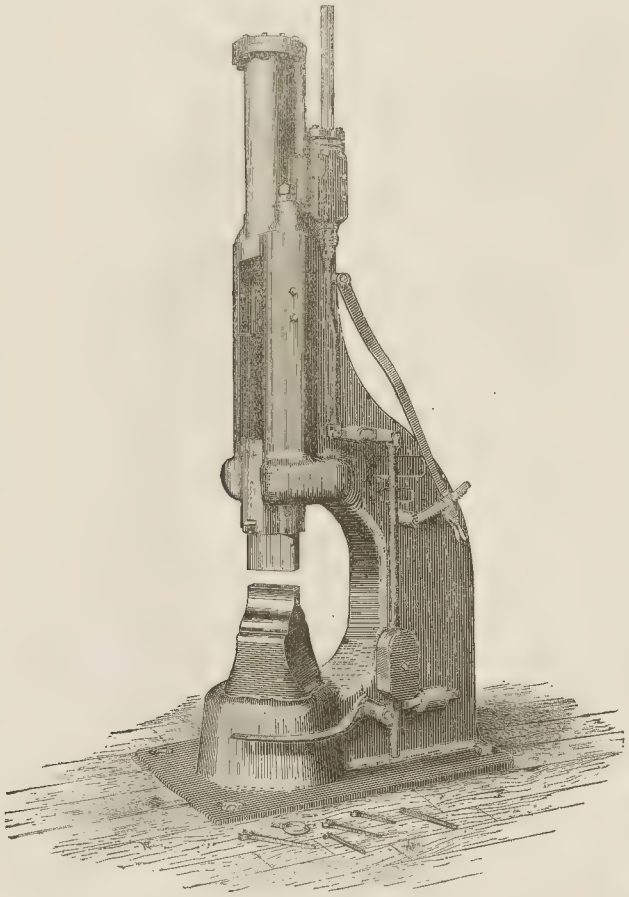


Fig. 24.

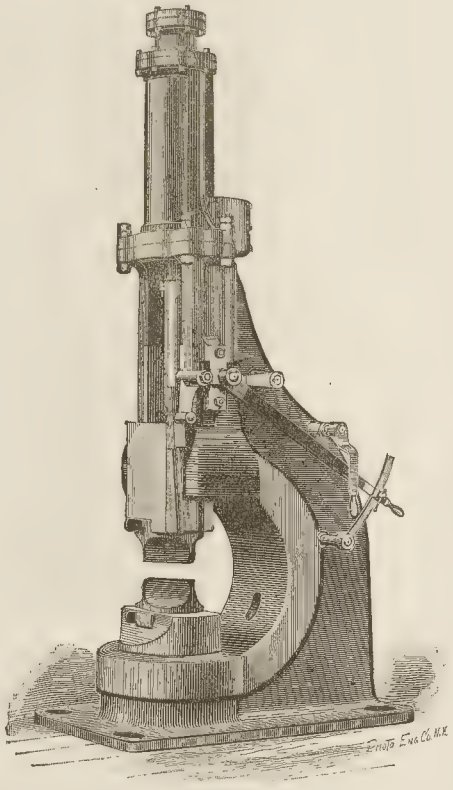


Fig. 25.

The advantage of this system is the free height between the anvil and the end of the hammer-bar. The cylinder also serves, in double-frame hammers (Fig. 27), to brace the uprights at the top. The anvil in these designs is made of five, seven, or eight times the weight of the hammer-bar and accessories. The other designers prefer a relation of one of hammer to ten of anvil.

The simplicity of the construction and mechanism of the steam-hammers of to-day seems to leave but little to be desired. They can be made to deliver elastic or dead blows at the will of the operator, and can be used as drop-hammers. They are therefore fitted for any class of work. They are rapidly displacing all other forms for certain duties, and even in shops driven by water-power they are finding their way. Where power is otherwise running to waste they may be driven by compressed air without losing many of their advantages.

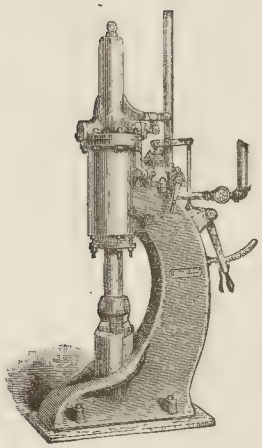


Fig. 26.

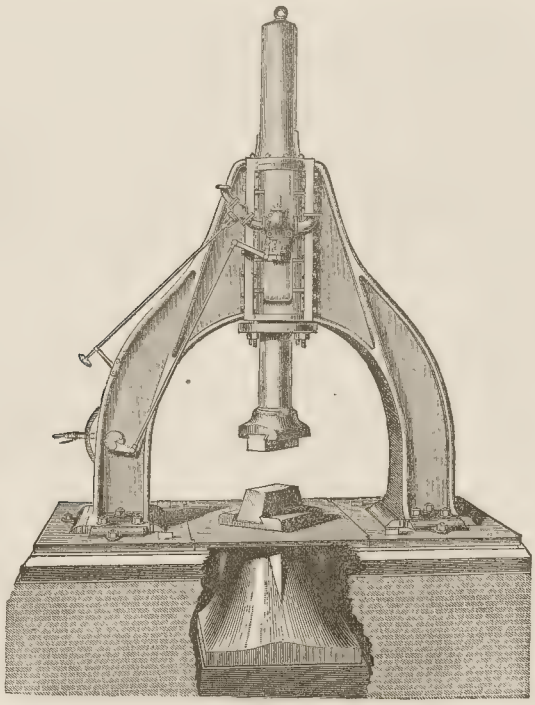


Fig. 27.

§ 6.

RIVETERS.

The next class of tools acting by compression are the riveting-machines. They act to compress and upset the metal of red-hot rivets in the holes of a lap-seam of plate-iron. They also form a head upon each end of the rivet, which bind the joint together by the shrinking of the shank as it cools.

Riveting-machines are of four classes: Power-riveters, steam-riveters, air-riveters, and water-riveters.

The essential parts of a riveting-machine are, first, a stationary stiff post or bolster, which shall serve as an abutment or anvil for the upsetting of the rivet. This bolster carries a stationary die or swage on one side, near the top. The second essential part is a movable guided ram with a die in its end, which shall slide forward and compress the rivet between the moving and fixed dies. This will form the two heads and upset the shank into the holes of the plate so as completely to fill them. The third essential part is the gearing and apparatus for driving and retracting the movable ram. The first two parts must be common to all designs. The variations will be in the driving mechanism. The problem is the gradual exertion of great power through a short stroke.

The power-riveters receive their motion through a belt from the transmissive machinery of the shop. Probably the earliest forms were those in which the ram received its alternate motion from a crank. The rotation of the crank, driven by reducing-gearing from the belt-wheel, forced the die to compress the rivet until the crank came in line with the connecting-rod to the ram. This compression was of great power, since the crank and rod made an elbow-joint as they came into line, although the two links were of unequal length. The special difficulty of this system is that all the reaction of the compression has to be absorbed in rubbing surfaces, on the crank-pin and on the shaft-journals. These, of course, had to be of extra size and all parts had to be of extra weight if excessive wear were to be avoided. To meet this difficulty another form of machine was devised, in which the ram is forced out by a true elbow-joint. When the ram is back, the two links hang down in the form of an obtuse V. The center joint is raised and the links are thus straightened out into line by a cam revolving on a shaft below the links and driven by reducing-gearing, as before, from a belt-wheel. In both forms the gearing to drive the ram is engaged at will by a jaw-clutch. This elbow-joint form has several advantages over the crank-form. The strain is borne by the rigid back of the machine frame on large pin joints. The crank-machine had always to be disengaged when the crank was in one position, with the ram drawn back; the cam-riveter causes the ram to retire by the weight of

tne links as soon as released by the cam. The cam moreover may be so designed as to maintain pressure upon the rivet until it cools somewhat under the strain. This was inconvenient and difficult, if not impossible, with the crank-form. It is riveting by dead blows, which is impossible with a maintained connection between ram and driving power. Both tools have the advantage of giving a gradual compression to the rivet, which is most favorable for the flowing of the metal which is to fill the holes. They have, however, the disadvantage of being non-adjustable either in length or in force of stroke. For rivets of different lengths in plates of different thicknesses the only adjustment is by changing the swage-dies for others of different length. This is inconvenient and takes time. The effect of excessive compression is either to fray out the edges of the rivet-heads, permitting access of corrosives to plate and shank, or else a film of the rivet opens the lap-joint by squeezing in between the two plates. Finally, the frame of the machine has to be very heavy and deep to accommodate the links and to resist their reaction.

§ 7.

STEAM-RIVETERS.

In the steam-riveters the force of the crank or elbow-joint is replaced by the pressure of steam on a piston-head. The movable ram is secured on the end of the piston-rod from the steam-cylinder, and thus compresses the rivet.

Fig. 28 illustrates the general form of one type. Of this type there are two varieties. One uses a light ram, and depends solely upon the large piston area for the compression of the rivet. The other variety has considerable

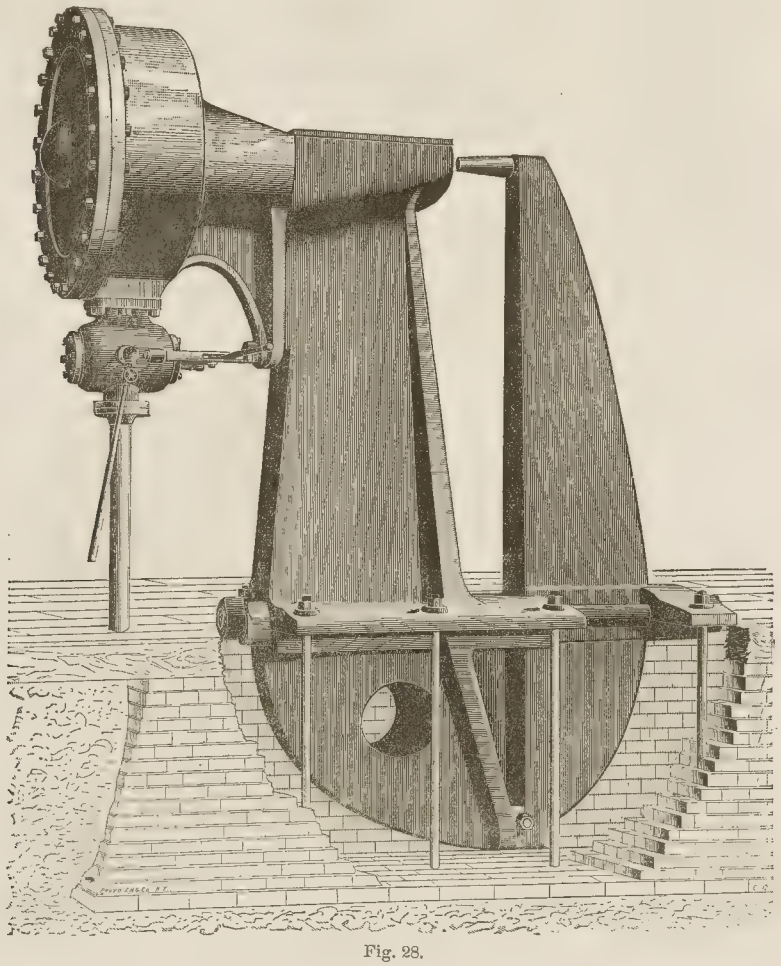


Fig. 28.

weight in the ram and piston, so that when in motion they shall have considerable living force. The compression is effected in part by the living force of this mass and a less diameter of cylinder, and therefore a less volume of steam

suffices for the same work as in the other case. This second variety is the approved form of present practice. The piston and ram are made of one large forging, and steam is admitted through a balanced valve behind the piston. After having delivered the blow some of the steam passes through an equalizing-port into the clearance in front of the piston, and by its expansion, when the exhaust-port is opened, retracts the ram. A second form of steam-riveter in use, but not manufactured at this date, has two cylinders connected to the swaging-ram by bell-crank levers in the horizontal riveters, or by links in the vertical machines. These cylinders are of different diameters, the smaller outer one being connected to the heading-die, while the inner and larger one works an annular ram, which holds the plates together while the heading blow is struck. It is much less simple than the prevailing form.

Steam-riveters, as a class, possess many of the same advantages which steam-hammers have over similar tools driven from shafting. The elasticity of the steam cushions the reaction against the cylinder-head. The position of the machine may be independent of the lines of shafting, since the steam-pipe can be carried anywhere. There is no loss of power nor loss by wear of gear during inactivity

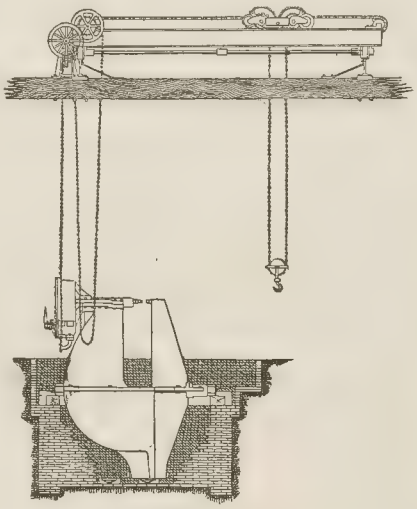


Fig. 29 *a*.

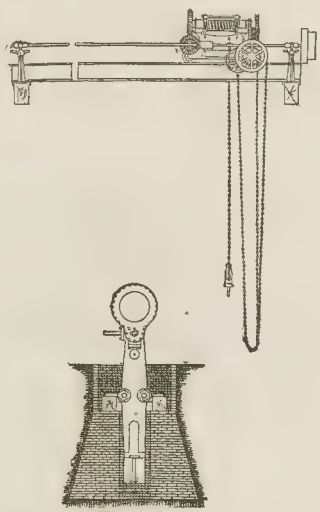


Fig. 29 *b*.

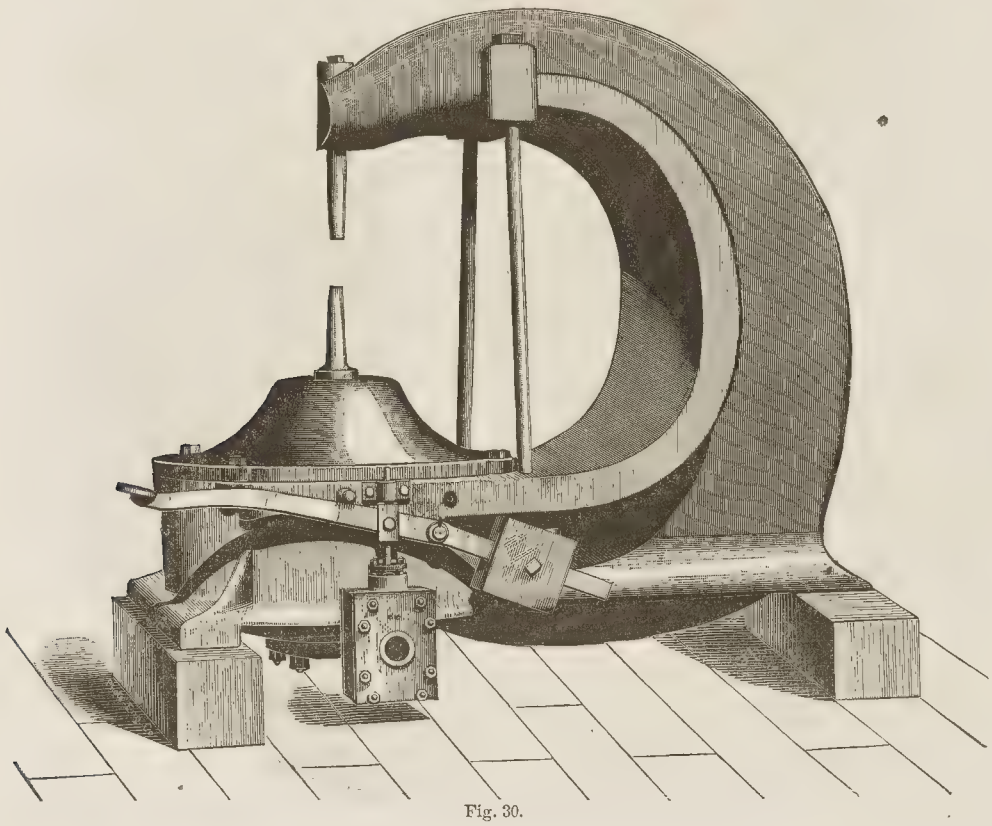


Fig. 30.

of the machine. On the other hand, they deliver a blow upon the rivet before the compression, which causes shocks upon the bolster or stake and wears and strains the machine. There is also a tendency to slide on the foundations, due to the impetus and reaction of the blow, which can only be counteracted by heavy foundations and anchor-bolts. Figs. 29*a* and 29*b* show a similar machine with the overhead traveling carriage which accompanies it in the best practice, and Fig. 30 illustrates a horizontally-bedded machine for bridge-work worked by a foot-lever.

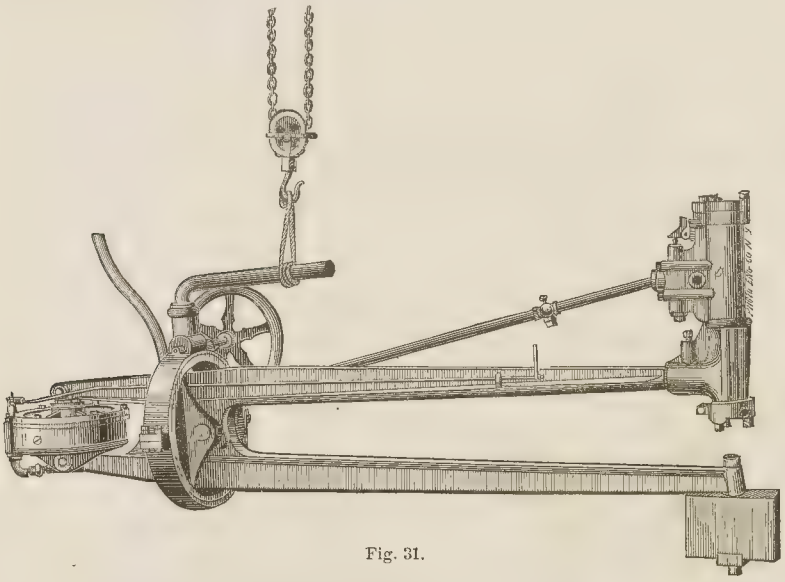


Fig. 31.

able and avoids the expense of foundations. Fig. 31 shows its construction as adapted for boiler-work. The two long arms are pivoted in the suspension ring, which is double, and can be adjusted by the worm and wheel so as to act upon the rivet at any angle. At the farther end is a wide but short cylinder by which the acting ends can be brought together upon the plates before the rivet is inserted. This clamps them together and increases the stiffness of the hold of the stake-arm upon the rivet-head. Upon the free end of the other arm is a small cylinder, with a rivet-swage upon the end of the piston-rod. This small cylinder delivers a number of blows upon the rivet when in place, heading it over upon the clamped plates. About one hundred and fifty or two hundred blows will be delivered per minute, the valve-motion of the cylinder being not unlike that of a rock-drill. The stake-arm has a counterpoise to increase its mass, and the whole machine is swung over its center of gravity. Thirty pounds per square inch is usually sufficient air-pressure.

For work upon girders, where the overreach need not be very large, the form shown in Fig. 32 is used. The machine acts by compression, and not by blows. The air-cylinder opens and closes the links of an elbow-joint upon the outer ends of the nipping-levers.

This form of riveting machinery has the advantages due to its portability, inasmuch as the heavy work does not need to be adjusted to the machine. It also works very rapidly, and steam can replace the air if desired. It is claimed for it that on straight work it will head over two rivets per minute.

§ 8.

AIR-RIVETERS.

The steam-riveter can be worked by compressed air with but little less efficiency. But an especial riveting device to work by air has been introduced which depends upon a different principle. The machine is port-

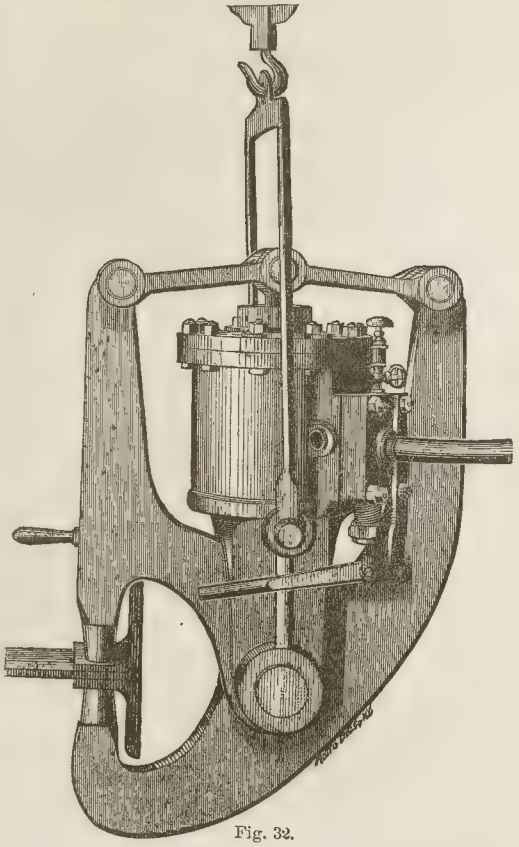


Fig. 32.

§ 9.

WATER OR HYDRAULIC RIVETERS.

The hydraulic riveters differ from the preceding types in the use of an inelastic fluid under great pressures behind the plunger in a smaller cylinder. On account of its density water can be retained at a high pressure per each

square inch, and this pressure upon a small area produces a force equal to that due to lighter steam pressure on a large area. The stationary riveter will, therefore, resemble the steam-riveter, but the cylinder will be much smaller (Figs. 33 and 34). Two essential parts of this hydraulic apparatus must be the pump to produce the water-pressure, and the device known as the "accumulator", to keep the pressure uniform. The pump may be driven by steam directly or by a reducing-gear from a belt-wheel. If the pump were to be the sole dependence to work the riveting-ram it would need to be stopped after each rivet, and would need to have a capacity to fill the barrel of the riveter before the rivet should cool. By the use of the accumulator both these drawbacks are avoided.

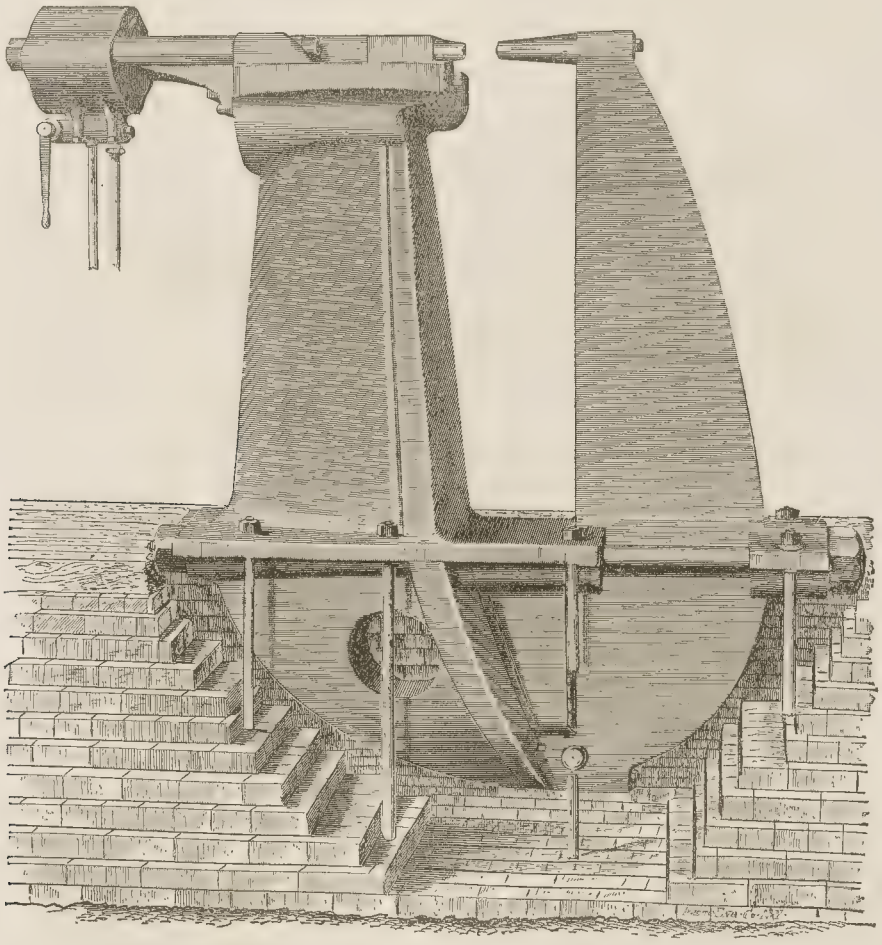


Fig. 33.

The accumulator (Fig. 35) consists of a plunger, which plays through a stuffing-box in the top of a pressure reservoir. Into this reservoir the water is delivered from the pump, and from it is carried to the riveters by pipes, controllable at the machines by valves. It will be seen that when the pumps deliver water into the reservoir, with the outlets closed, the plunger will be floated upward by the accumulating pressure upon its lower end. When an outlet is opened the plunger will sink as the water is withdrawn, but will still maintain the equilibrium between its weight and the pressure of water in the reservoir. By adding weight upon the plunger any desired pressure can be maintained. These weights are hung from the top of the plunger, so that their release or addition can be effected without lifting them into place. When the reservoir is full of water at the desired pressure the accumulator-plunger will be at its highest point. Should the pump continue to force water into the reservoir, the plunger would be forced out. To avoid this, when the plunger has risen to a certain point it opens the valve shown in front by which the forcing-side is connected to the suction-side of the pumps, while the accumulator pressure is shut off. The pump keeps on working under no strain, no more water is added to the accumulator, and yet the pump will resume its normal duty as soon as any water is withdrawn by the machines. Where the pumping is done by a steam-pump, the accumulator-plunger may be connected to a valve in the steam-pipe. When the plunger rises

the steam supply is diminished, as it falls lower the speed of the pump is increased because more steam is given to it. The upright of Fig. 35 is a hollow tank into which the water returns after it is exhausted from the riveters. The water is filtered through sponge on its return to remove any scale, etc., which may have been loosened.

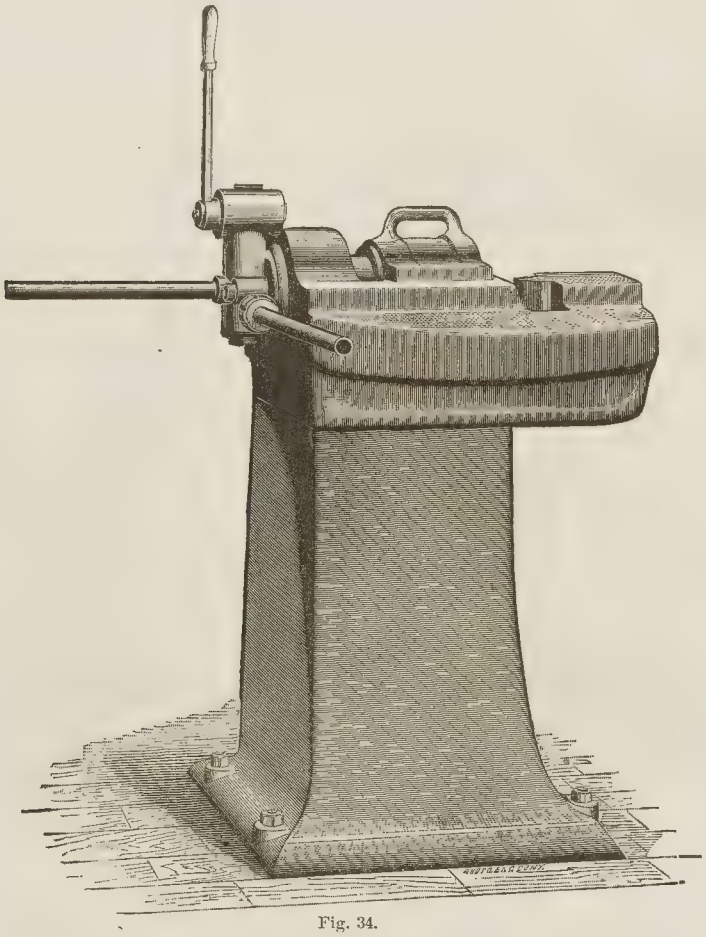


Fig. 34.

For bridge-work, the portable machines shown in Figs. 36 *a*, *b*, and *c* are approved. The machine is hung on the arc from an overhead carriage or from a traveler. It can be presented at any angle to the work, and a worm and wheel gives adjustment in the plane at right angles to the arc. The jaws are levers of the third order, pivoted on a ball-joint at the long ends and held from separating by a spiral spring. Water from the accumulator is admitted to the plunger through a valve and draws the dies together. A reverse motion of the valve-lever shuts off the pressure and opens the exhaust-valve. When the exhaust-valve is open, a small piston attached to the bottom of the barrel serves to draw back the plunger and open the dies. It is claimed for this machine that with it a skillful operator can drive from ten to sixteen rivets per minute in straight work upon girders.

The great advantage of the hydraulic riveter is due to the fact that it compresses the rivets without a blow. The great density of the driving fluid permits its gradual flow through the controlling-valve, and as it has no expansive force of its own, the advance of the ram upon the rivet is a gradual one. The pressure upon the heads of the rivets can never be any greater than that due to the previously determined load on the accumulator. Therefore, the plates can not be forced apart in the joint nor distressed by any excessive pressure in the upsetting. They have hitherto been open to the drawbacks due to the high pressures at which they were worked. An average pressure was from 1,000 to 1,800 pounds per square inch, but this pressure is very severe upon the packing of the rams. Leather cup-packing seems to give the best results, but it is cut sharply through at the bends. Practice is therefore tending to reduce the pressures and enlarge the plunger areas. Pressures of 350 pounds to the square inch are much less difficult to manage, and the advantages of riveting by an inelastic pressure are retained. For girder-work in yards, or under open sheds in winter, there may be dangers from freezing of the water, against which special precautions must be taken.

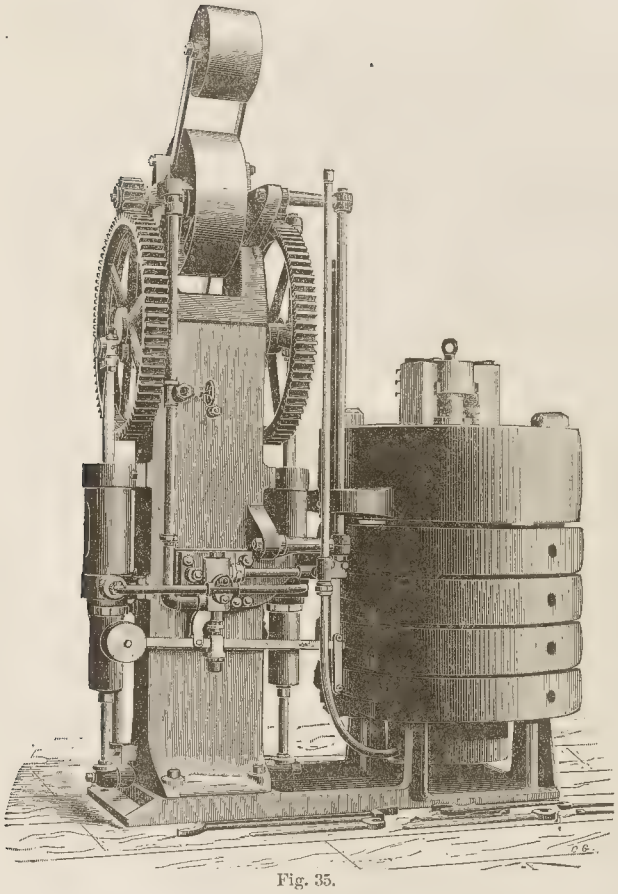


Fig. 35.

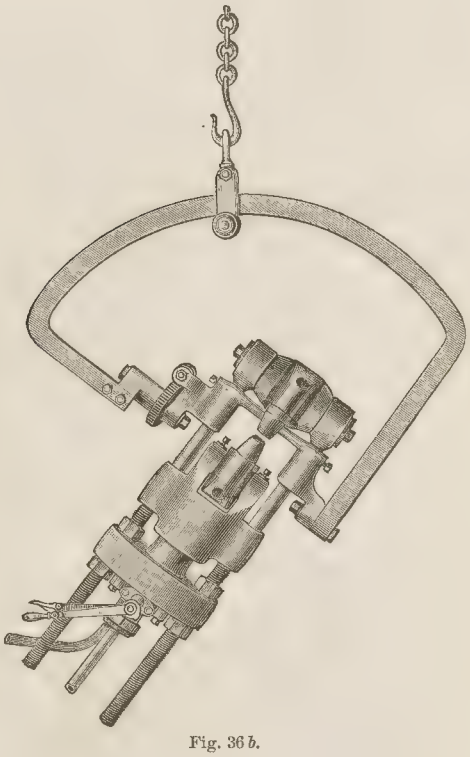


Fig. 36 *b*.

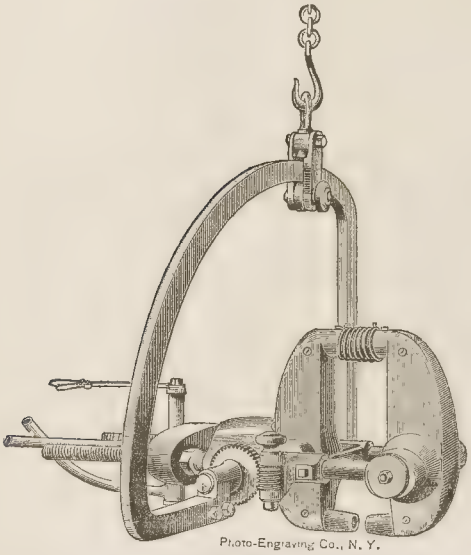


Photo-Engraving Co., N. Y.

Fig. 36 *a*.

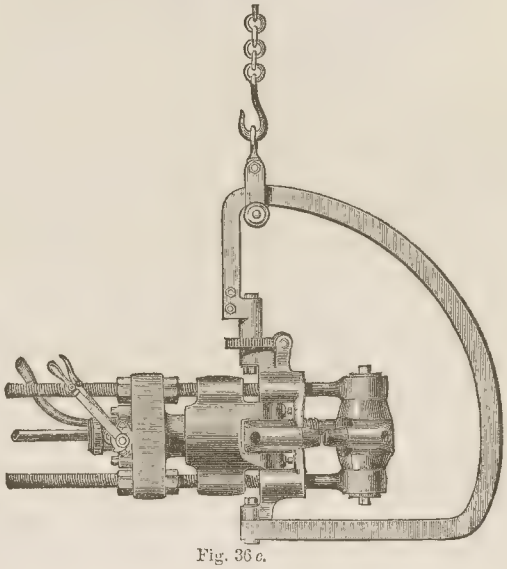


Fig. 36 *c*.

§ 10.

DIE-FORGING MACHINERY.

The principle of these machines is but an extension of that on which hydraulic riveting is based. The material to be shaped is exposed at a welding heat to great pressures between dies which are actuated by hydraulic plungers. Every part of the die is completely filled by this pressure, and an exact reproduction is obtained. The effect of this gradual pressure upon the forging is much more favorable than the effect of hammer blows. Blows upon the

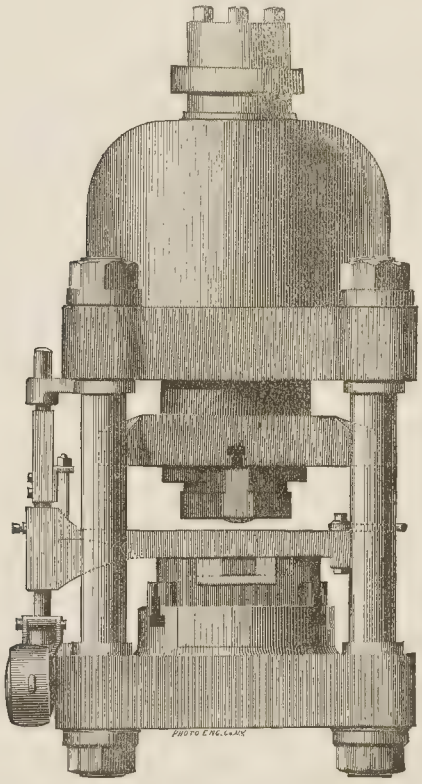


Fig 37.

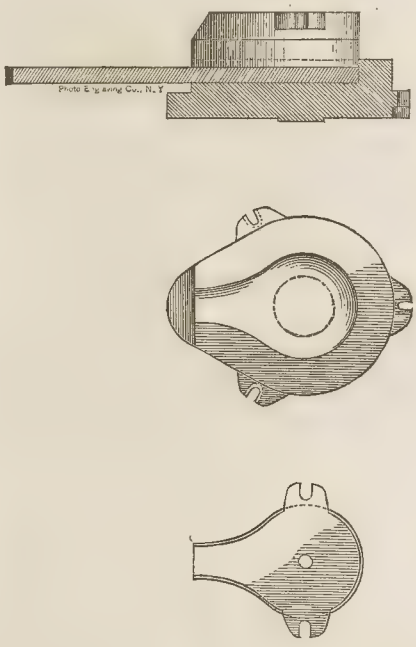


Fig 38.

forging delivered through a fuller or swage often act upon the surface only, and leave the interior parts less affected. This is shown by the drawing out of the top and the bottom of a forging farther than the center. In rolling this phenomenon gives rise to "pipes". The gradual pressure forces out the material in the middle first, thus showing the compression to have been pervasive.

This process of die-forging has been applied with especial success to the manufacture of eye-bars or chord-links for bridges. The enlarged head or eye is formed from the metal of the bar without the weakening effect of a common weld, and with much greater economy.

Two sets of presses are employed. The first upsets the end of the bar into approximately the finished profile, while the neck of the bar below the heat is closely gripped between serrated jaws. The heat is restored to the end to relieve the strain at the neck, and it is put in a flatting-press with male and female die and brought to the exact shape and thickness (Fig. 37). A nipple on the male die makes a central depression upon the eye where the pin-hole comes (Fig. 38), which depression guides the punch which forms the hole. The punch is usually hydraulic—shaped and acting like a vertical riveter. The only loss of metal is by scale and the small fin at the dies. The punched blanks can be welded under pressure and utilized as nuts. One difficulty met with is the danger of thinning the bar at the joint of eye and straight length.

Two accumulators are used to furnish the hydraulic pressure for the presses. One is weighted to produce 400 pounds or so to the square inch of plunger, and water is taken from this to fill the plunger-barrel and to exert

what pressure it will. Then, if necessary, the first valve is closed and communication is made with the second accumulator, which is weighted to 2,500 pounds to the square inch. Less water at the heavier pressure is thereby

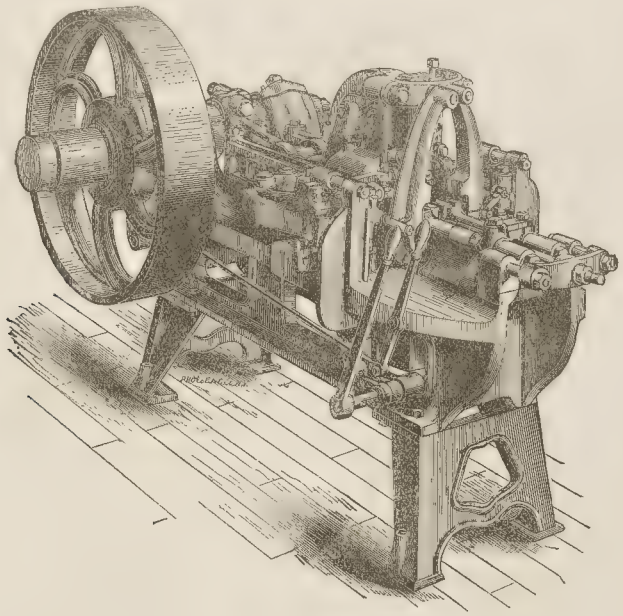


Fig. 39.

used, resulting in a saving of the power necessary, but many works are using only one accumulator to avoid the greater first cost.

This principle of forging between dies by hydraulic pressure can be carried very much further and applied to many shapes. The saving of time and the superiority of product are to be set over against the first cost of the plant.

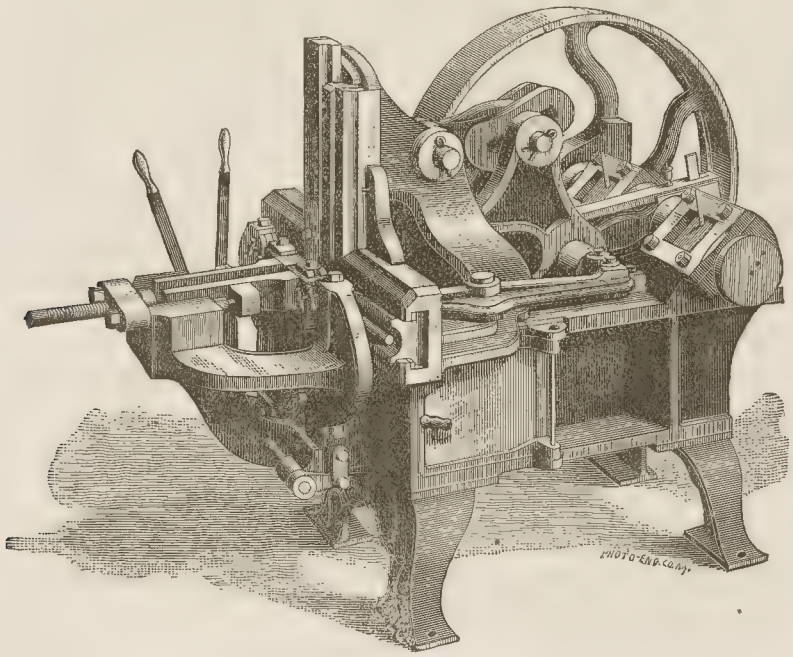


Fig. 40.

Another method upsets the end of the bar by pressure of a ram driven by steam pressure. The bar is held between plungers, from which hydraulic pressure is relieved through a small valve as the upset is made. This yielding grip is thought to distress the bar less than a rigid clamp. Upon the upset end a piece is welded to make up the thickness when the eye is formed between dies on head and anvil of a steam-hammer.

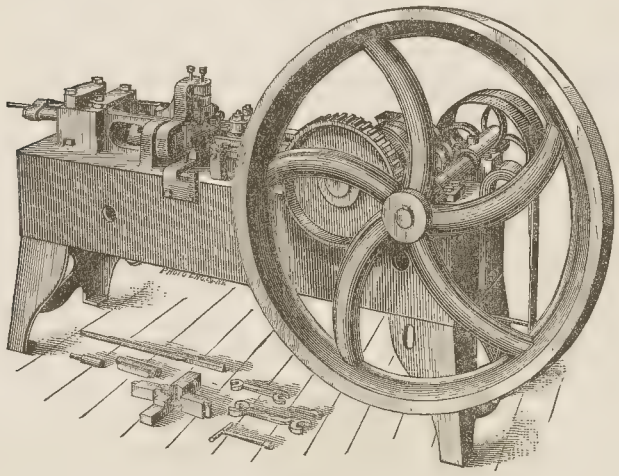


Fig. 41.

Under die-forging machinery must also be included the machines for making bolts and nuts. Many large shops which use a great number of bolts of different forms prefer to head over their own stock in the blacksmith shop, and for such work these tools are adapted. Fig. 39 shows the Burdict improved bolt-forger; Fig. 40 is the Abbe machine, an outgrowth of the former, and Fig. 41 shows the Burdict machine for making hot-pressed nuts from the bar.

In the bolt-header (Fig. 39) the iron is held between clamp-dies which are moved by the hand-lever at the extreme right. The grip is by means of an elbow-joint, and is for steadiness only. The blank is kept from end motion by a screw-stop at the end of the vise. Hence there will be no change of section of the rod under the heated head. Blows are delivered upon the end of the blank by the upset-die, which is connected to a short crank on the fly-wheel shaft, and the forming-dies in pairs act laterally upon the upset metal. The formers act twice for every one blow of the upset. The forging-levers act only when engaged by a clutch operated by the second hand-lever, thus avoiding unnecessary wear. The slides of the formers are gibbed to take up wear, and the pin-joints are bushed. The links from the long slide of the upset make an elbow-joint combination with the side levers, and the top and bottom swages are moved by a pin working in a curved slot. Four revolutions of the shaft will form a head, and from 3,000 to 8,000 bolts is the capacity of the machine in ten hours.

Fig. 42 illustrates another type. The nut-machine (Fig. 41) makes the nut at one operation without fin or burr, saving the expense of trimming the blanks.

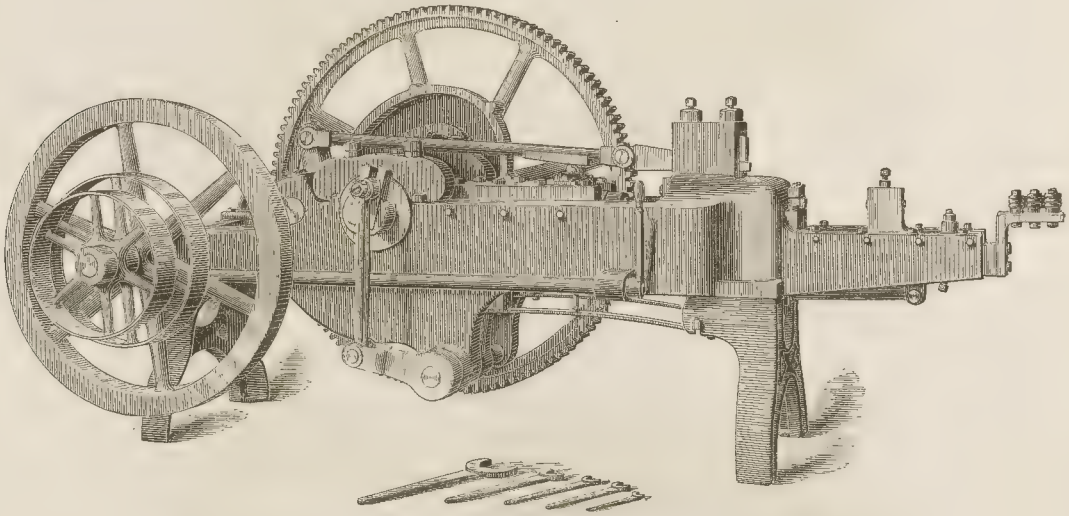


Fig. 42.

There is a variety of other machines which might come under this class, such as the rivet, spike, nail, and horse-shoe machinery, but as these are machines manufacturing directly and only for the market, in accordance with the original plan they will be passed over.

§11.

BENDING-ROLLS—STRAIGHTENING- AND BENDING-PRESSES—ASSEMBLING-PRESSES.

BENDING-ROLLS.

For curving plate iron or steel for boiler purposes, or for other cases where cold shaping may be required, the combination of three rolls is used. This appears in two forms. The two lower driven rolls may be fixed, and lie in the same horizontal plane, while the third roll lies above the other two and over the hollow between them. This top roll is adjustable vertically to give the required degree of curvature. The other form has the upper and one lower roll fixed and driven, while the third roll is adjustable obliquely toward the other two (Fig. 43). The adjustable roll is not driven in either case. The first form has the advantage of causing no calendering action. The curving takes place round the adjustable roll, which is not driven, and the two driven rolls both act upon the outside surface. The disadvantage is that it is not

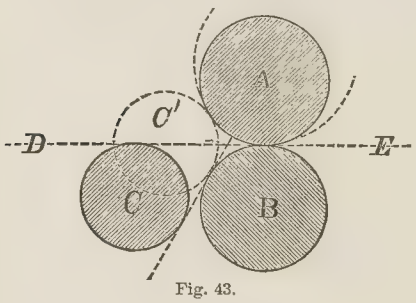


Fig. 43.



Fig. 44.

easy to start the plate into the rolls, and that they will not curve it exactly near the edges of the plate. In the second form the two driven rolls pinch the plate, so that it must enter, and the third roll bends close to the edge.

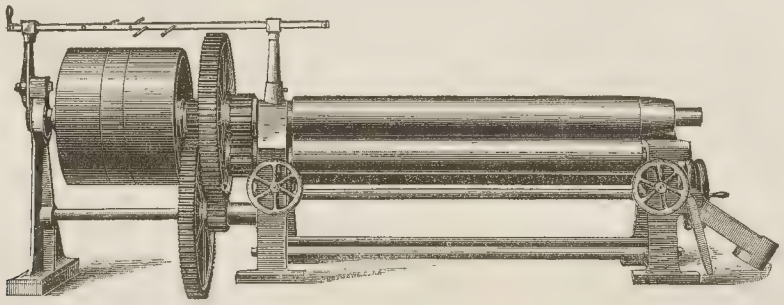


Fig. 45.

But the upper roll is acting upon a surface of less length than the lower after the piece is curved, yet they are driven at the same speed. To obviate the frictional loss from this inequality the lower roll, in the best practice,

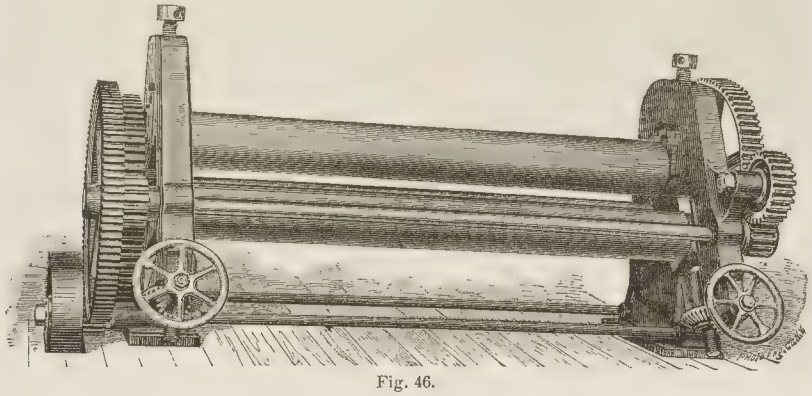


Fig. 46.

is driven by an epicyclic gear, so that the excess of length may be compensated for and pass into the gear (Fig. 44). This avoids also the calendering of the plate. The compensating gear consists in a set of four bevel-wheels forming a rectangle, the two smaller ones being upon a diameter of the wheel which drives both rolls, and of the other two, one is connected to the gear on the upper roll and the other to the gear of the lower. Any inequality of resistance in the rolls is equalized by the rolling of the small bevel-wheels upon the larger. The rolls are geared at both ends by large gears and small pinions, so that they shall drive truly. They are driven by open and crossed belt, with one fast and two loose pulleys. The shifters may either be plain forks, or else some of the special designs may be used, by which one belt is shifted off before the other is shifted on. The housing of the upper roll is made removable, in order that flues or any other work rolled into a full cylinder can be taken off. In the form shown in Fig. 45 the roll need not be lifted that the flue may clear. The design of Fig. 44 makes the lifting necessary. The screws for lifting the two ends of the curving-roll are usually geared together, that true cylindrical curvature may be given. When the plates are to be bent into-wind, as in ship-work, they may either be presented diagonally or the two ends of the curving roll may be raised unequally (Fig. 47). In the pyramidal form the rolls must be brought together with the work between them. Not infrequently, therefore, the adjusting-screws are headed by worm-wheels and driven by power. With the other form hand-gear only is necessary, and is preferable from its greater exactness (Fig. 46).

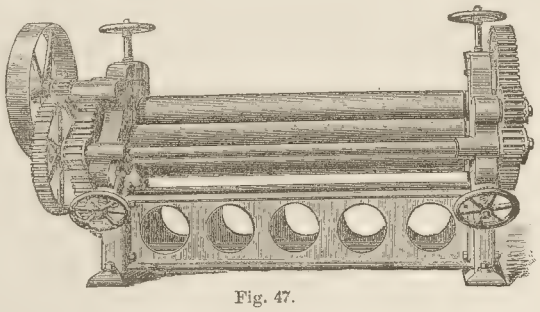


Fig. 47.

Where the rolls are revolved by hand-spikes, and one lower and the upper roll may be driven, the pyramidal form is approved, because of its simplicity. For power-driven rolls, the other arrangement is preferred.

§ 12.

STRAIGHTENING- AND BENDING-PRESSES.

After work has left a roll-train and has become cool, it is very often found to be out of true. Unequal contraction, if the work was finished hot, may produce this result, the shape may have compelled calendering, or the removal of a skin which kept the work straight in the rough may also cause it. In either case straightening machinery is made necessary.

To straighten a curved beam or rail a heavy pressure is to be exerted upon the work through a short distance, while it is held upon two supports. The machine may be either horizontal or vertical, and usually acts upon the principle of the crank, the crank and connecting-rod forming an elbow-joint combination. The essential parts will therefore be the two abutments for the support of the work, and a crank-shaft which can be adjusted with respect to the abutments for different thicknesses of work and different amounts of curvature.

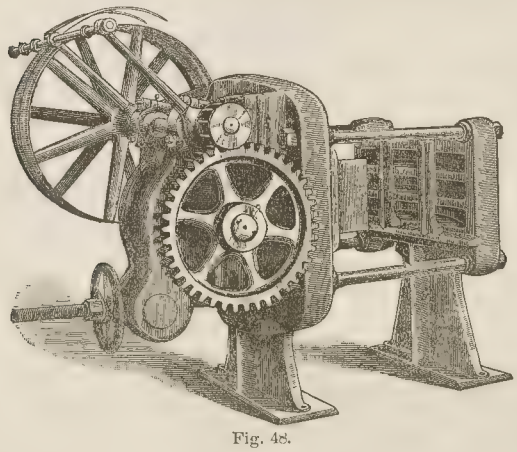


Fig. 48.

Fig. 48 shows a horizontal machine of this class. The abutments are tied to the plunger frame by the four bolts, and the bearings of the crank-shaft are borne upon the heavy frame swinging around the center of the pinion-shaft. By tightening the hand-wheel nut the end of the bending-plunger comes nearer to the abutment. The gear-wheel travels around the pinion, always remaining in gear with it. A vertical machine for similar purposes is also made, whose mechanism resembles closely that of the vertical punches. The horizontal machine is especially adapted for working upon bridge or other girder work, as the parts lie horizontally upon trestles, at an easy height for sighting. By raising the height of the abutment supports of these machines, they can be used for curving straight work for any uses for which such pieces may be required.

Fig. 49 illustrates a hydraulic machine for curving railroad-iron. The abutment may be changed for different degrees of curvature, and the bending speed may be varied by the lever without stopping the pump.

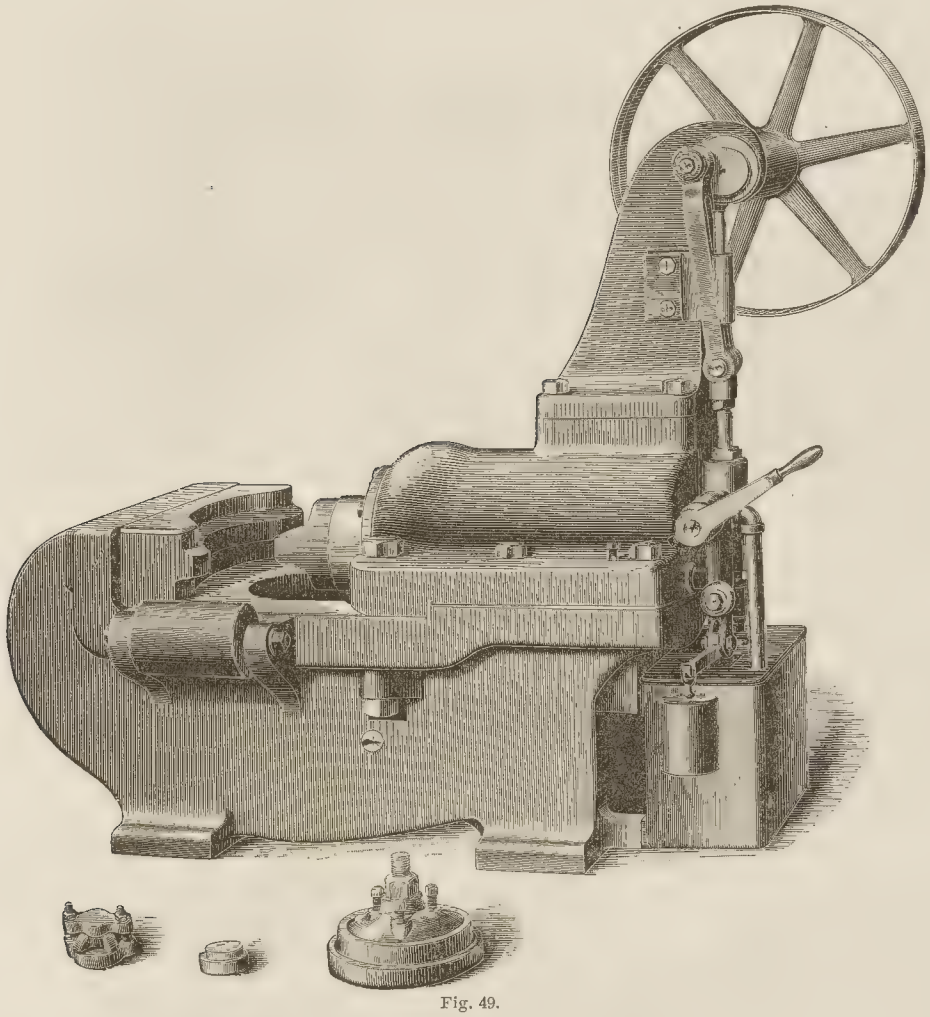


Fig. 49.

§ 13.

ASSEMBLING-PRESSES.

Under this head come those machines which are used in putting together the parts of engineering work. They are most generally applied for putting crank-pins into cranks, and for forcing the wheels of cars and locomotives upon their axles. The principle of the hydraulic press is most generally applied, inasmuch as that has the advantages of slow velocities and very great power, and the exact pressure can be known by a pressure-gauge. The machine must consist of an abutment to resist the pressure of the ram, the supports for the work, the cylinder and frame for the ram, and the pump and its gear.

Figs. 50, 51, 52, and 53 show the general forms. The pumps are usually double, to insure regular motion of the ram. Designs (Figs. 52 and 53) have the pumps of different diameters. When the larger one is working the ram moves rapidly. When the limit of its capacity is reached it can be shut off by a hand-wheel, and the smaller pump will complete the pressure to the limit of the machine. At 100 strokes per minute no irregularity of motion is felt. The fluid used is oil taken from a reservoir in the base of the frame. When the work has been forced home, the pressure can be let off into the reservoir by turning the large hand-wheel and the ram is retracted

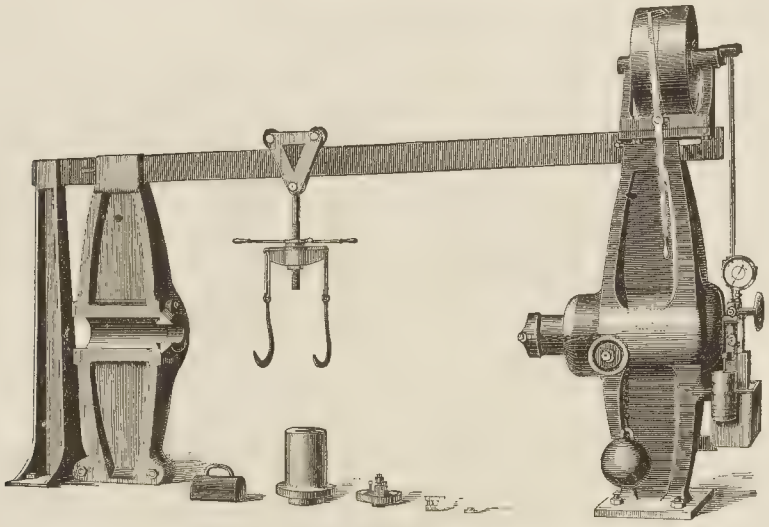


Fig. 50.

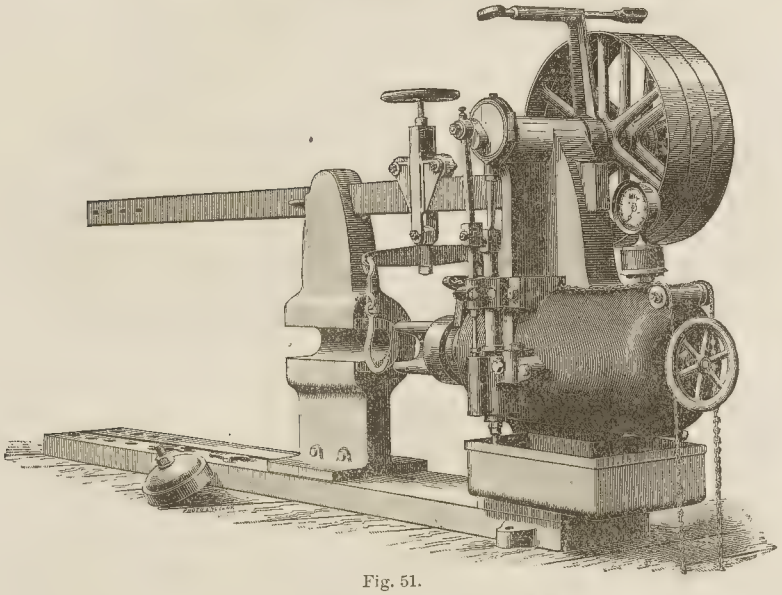


Fig. 51.

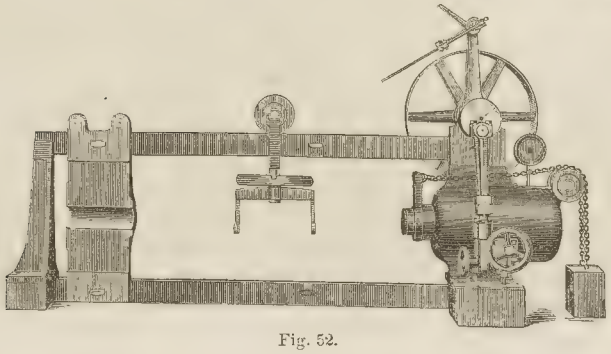


Fig. 52.

by the counterpoise. The ram-cylinder is provided with a safety-valve (often put beyond the control of the operator) and a pressure-gauge. To prevent the sweating which cast iron will manifest under high pressures, one builder lines the cylinder with seamless copper expanded against the lining. Cup-leather packing is used for the gland, made upon formers which accompany the machine.

The abutment is tied to the ram-cylinder casting by the sole-plate below and the reach-rod above. The abutment is fitted with rollers either above or below to make easy the adjustments for different lengths, and is held in place by keys at top and bottom. It can thus be used to take apart work as well as to force it on. From a buggy on the reach hangs an equalizing beam, adjustable for different diameters by the screw- and hand-wheel. It will support any work in the line of the axis of the machine and over its center of gravity.

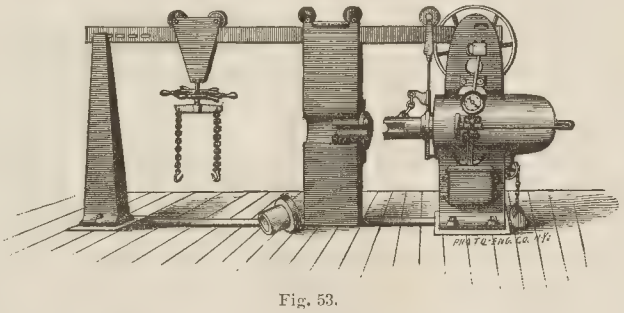


Fig. 53.

These assembling-presses have become almost a necessity. In car-axle work, where the "wheel-fit" on the axle is made cylindrical and seven-thousandths of an inch larger than the hole in the wheel, practice has shown that the wheels will never come off when forced in place by a pressure of 30 tons. To get this by the old hand-screw press would be very laborious and would take entirely too much time, while it would be hard to ascertain exactly what pressure was being applied. The hydraulic press avoids all these difficulties, and is therefore in very general use.

§ 14.

B.—TOOLS ACTING BY SHEARING.

This class includes those tools which act upon the metal by cutting through or cutting off the fibers or elongated crystals of which it is composed. This may be done by perforating the metal as when a plate is punched, or by separating it into two parts at a vertical plane as when a bar is sheared.

The tools in this class will therefore be the punches and the shears. They can be discussed together, since their action and construction are identical. There must always be found the abutment upon which the metal must rest, and an edge or plane through which the shearing force will pass. In the shearing-machines these two are straight; in the punches they are circular.

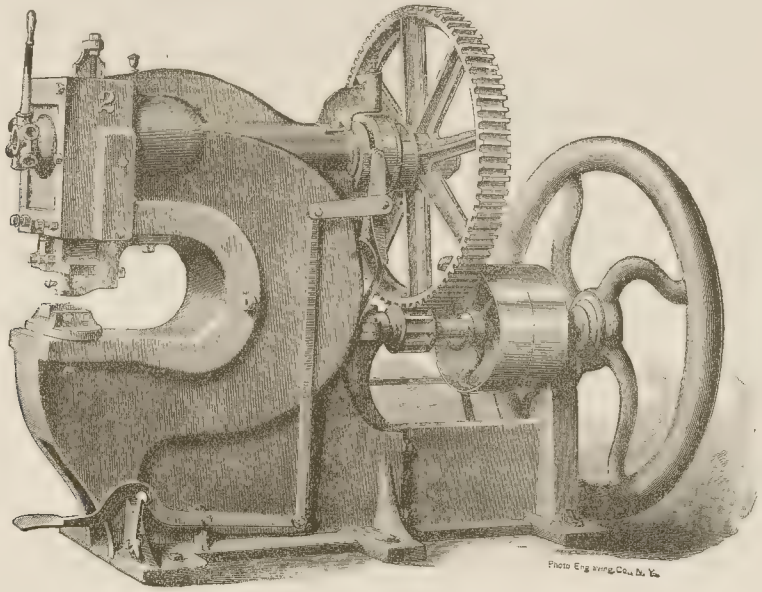


Fig. 54.

Shearing-machines may be reciprocating or rotary. Punches can be reciprocating only, from their nature. They are usually driven by belting from the line shafting of the shop. Increasingly, however, practice is tending toward the use of a separate engine for each large tool of this class. The cylinder is bolted to the framing, and it

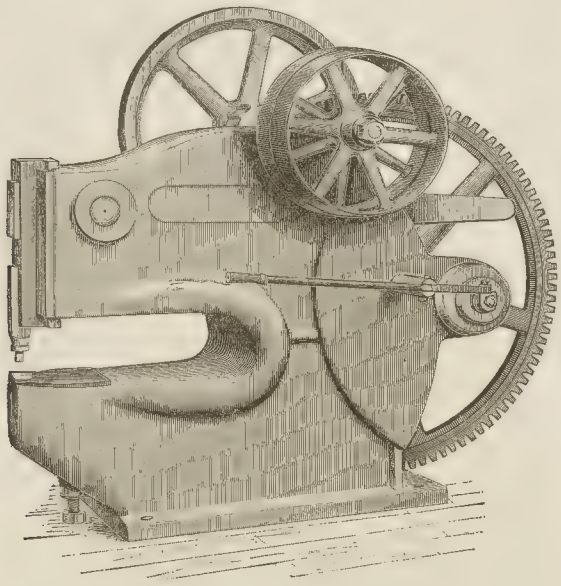


Fig. 55.

uses the former belt-shaft for its fly-wheel shaft. This system has the advantage of rendering the tool independent Any stoppage of the machinery does not arrest its work, and it can be put wherever most convenient, without regard to the conditions imposed by shafting, etc.

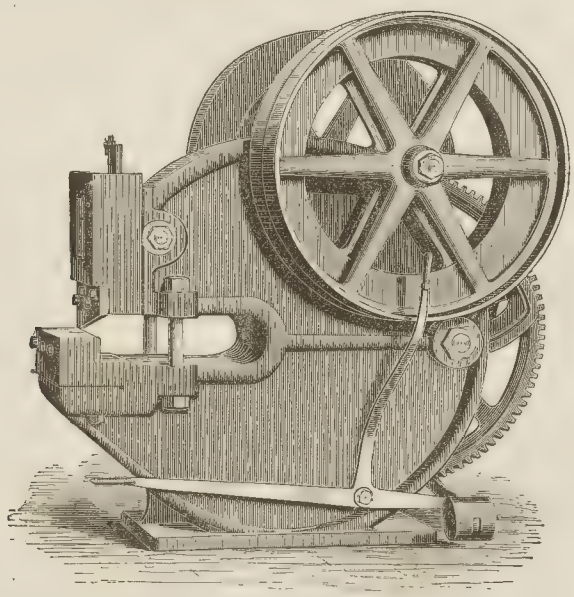


Fig. 56.

The reciprocating machines, punches, and shears can be grouped under two classes. The first includes those in which the slide carrying the shearing-plane is moved by a crank or eccentric. The second class includes those in which motion is given through a lever to the shearing-plane.

The disadvantages of the crank-system are that the strain of the cut must be borne upon the crank-pin, which must necessarily overhang, and the power of such machines is limited to the pressure practicable upon rubbing surfaces of the area of the pins. These rubbing surfaces being therefore, of necessity, large, the work of friction

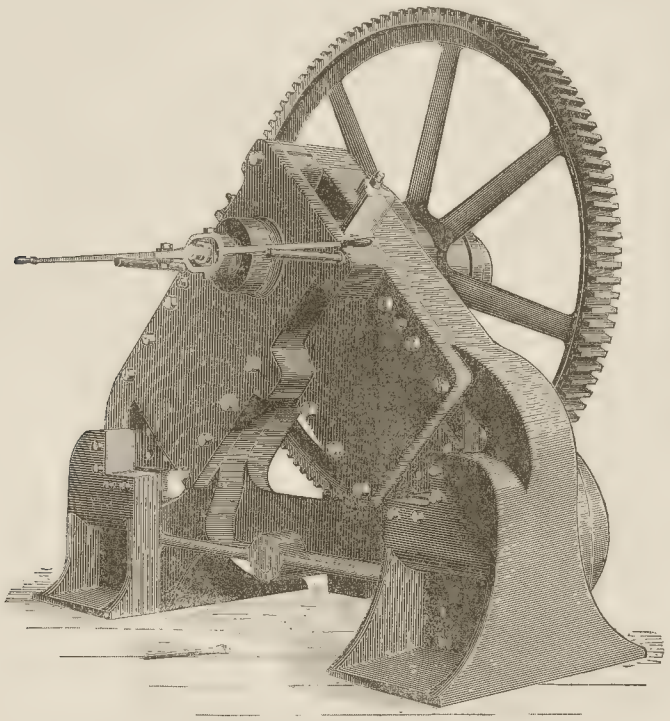


Fig. 57.

upon the circumference of the pin is also large, absorbing some of the power of the machine. The crank-system has the advantages of compactness, of distributed pressure upon the crank-shaft bearings, and of ready adjustability

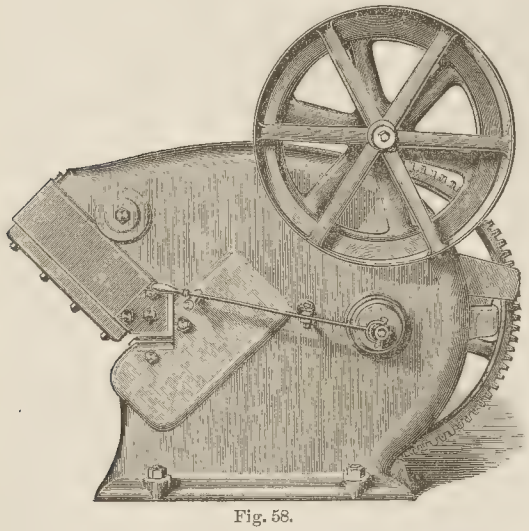


Fig. 58.

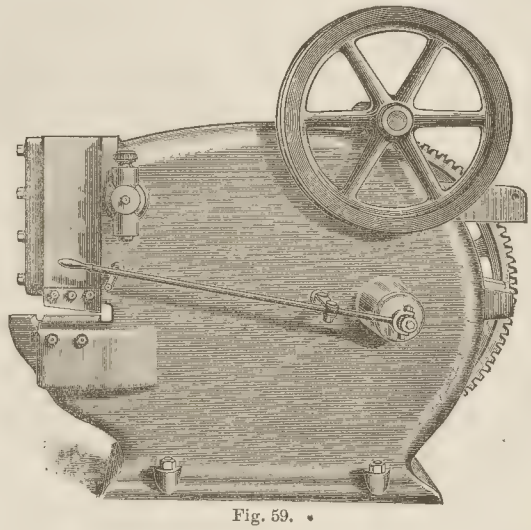


Fig. 59.

from in front. The power of the crank as it straightens into the line of the cut is very great. The disadvantages of the lever-system are that the necessity for metal at the fulcrum diminishes the capacity of the machine, and the

cam should have a double bearing to prevent the slide from being caught down, since, when released, the lever will fall with a heavy blow. Moreover, the stroke and release are of the nature of a shock, which causes the metal of the lever and of the frame to become fatigued.

The advantages of the lever-system are the diminished sliding of the rubbing surfaces at slide and at fulcrum, where pressure is great, while the cam at the long end of the lever works under lighter pressures, so that the work of friction is lessened. Moreover, the cam may be shaped to give a quick-return motion, and to permit the shearing-plane to remain stationary at the top of its stroke during a large part of a revolution. This makes the handling of work more easy, and may prevent the necessity of stopping the machine after a stroke.

In view of the close equivalence of the reasons in favor of the two systems, the prevailing practice favors both about equally. Most engineers prefer what they have been accustomed to.

Fig. 54 shows a very good illustration of the crank-punch or shear. A fast-and-loose belt-wheel shaft, carrying a fly-wheel, drives a pinion which turns a large gear loose on the crank-shaft. This gear can be clutched to the

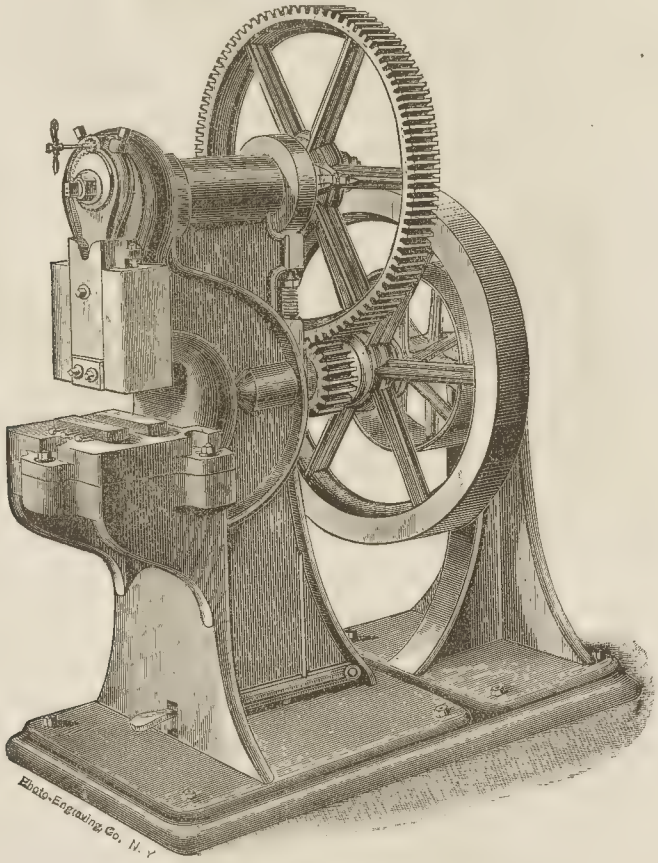


Fig. 60.

crank-shaft by the foot-treadle or by hand-lever. The fly-wheel equalizes the work of the single-acting plunger. The crank-shaft in this design is prolonged through the cap in front of the plunger, in order that the shaft may be turned by hand for accurate location of the punch before the power is applied. The punch is carried in a taper socket in the base of the plunger. Shear-plates bolt against a shoulder upon the wide, flat side. The inoperative components of crank-motion are very often taken up in a slide-block working in a rectangular opening made in the plunger, with arrangements to take up wear. Other plans use a short connecting-rod with wide bearings.

Below the punch is the abutment or die for the support of work. This is made of a diameter larger than that of the punch by two-tenths of the thickness of metal operated upon. This causes the punched hole to be tapering, but makes the extrusion of the blank more easy, and probably for that reason distresses the plate less. The cutting-edge only acts to sever the fibers for a very short distance. Below that it is the compressed metal of the work which acts to shear, and as this naturally widens as it goes down, the blank forced through is conical in shape.

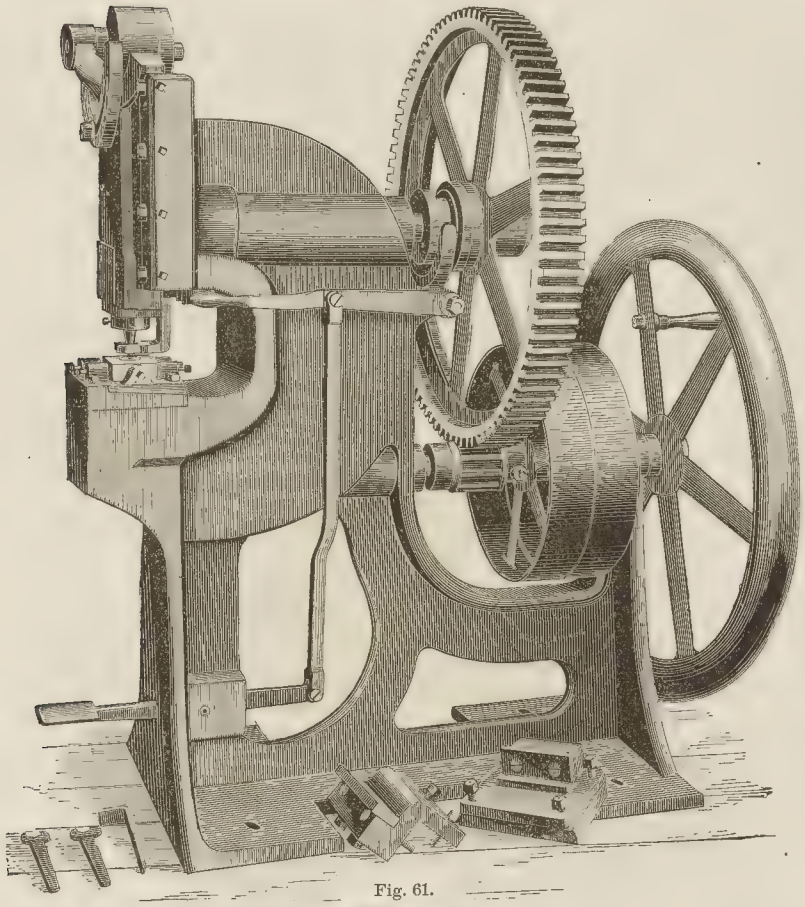


Fig. 61.

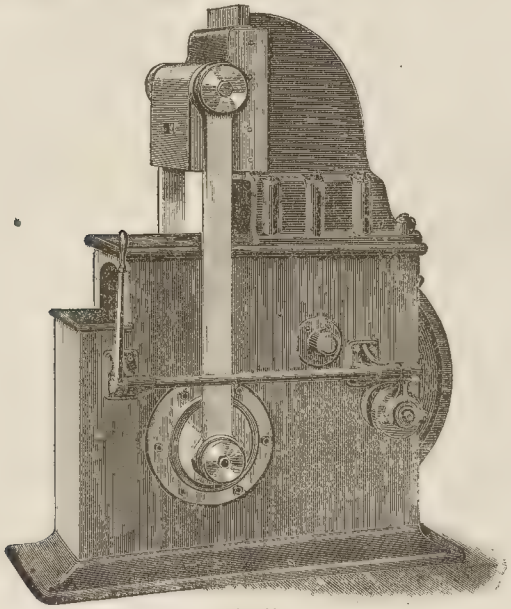


Fig. 62.

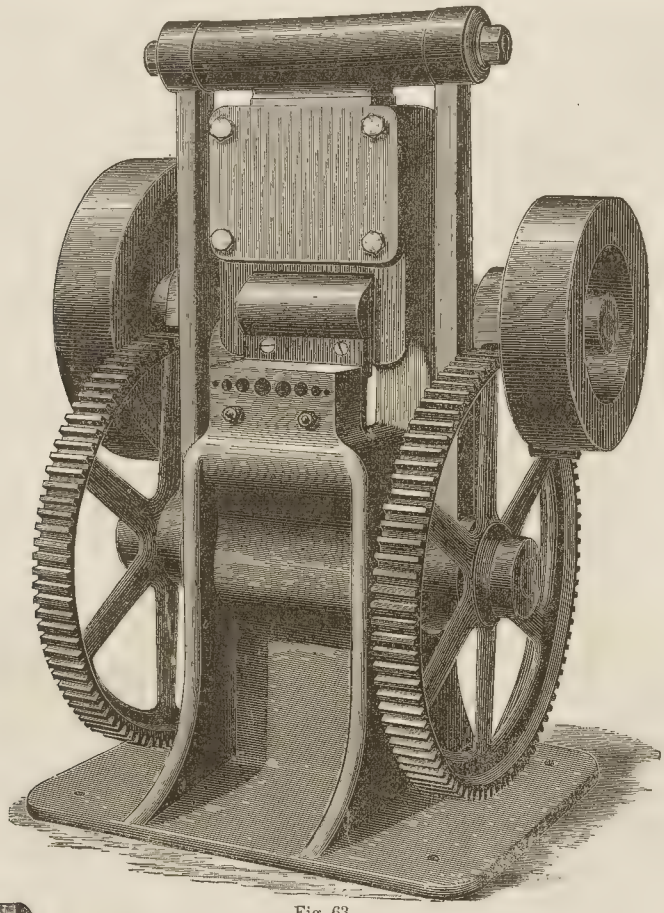


Fig. 63.

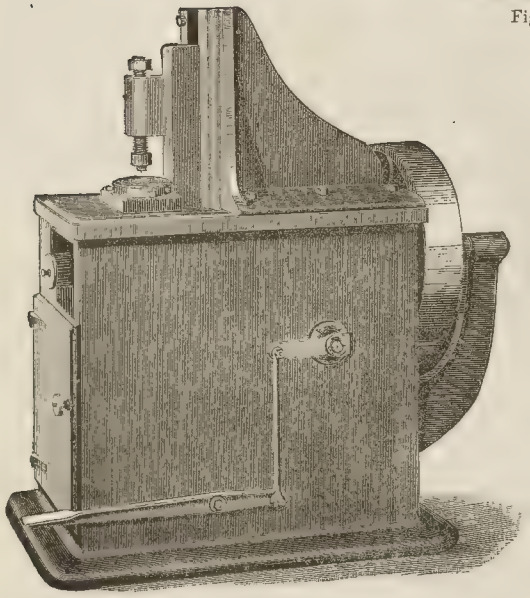


Fig. 64.

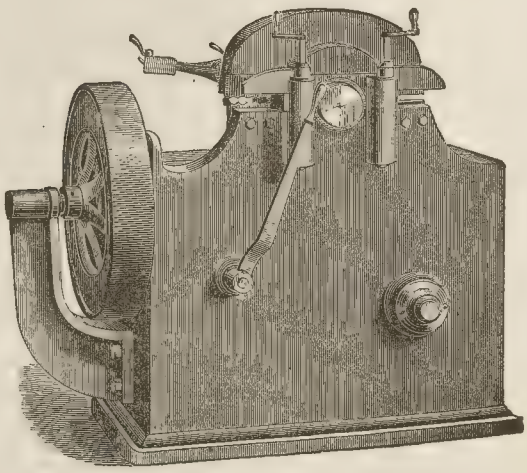


Fig. 65.

Should this conical frustum meet an abutment with a hole in it no larger than its smaller base, extra power would be required to shear this cone into a cylinder so as to fall through the hole. The abutments for shears are of a shape suited to their work. For round bars the blades should be shaped to segments of circles to take them in, else the sheared ends will be bruised and flattened when the cutting force comes upon a fraction only of the projected area of the bar. Strippers or "take-offs" are frequently applied to prevent the rise of the plate with the punch. They are adjustable vertically for different thicknesses of work. Figs. 55 and 56 illustrate the modern form of lever-punch and shear. The punch is put at the very front of the machine, which is made narrow so as not to obstruct the view. The die-seat is cut away like the horn of an anvil to enable flanged work to be handled. The holes can be punched to within one inch of the corner. In the shears the tools are fitted upon interchangeable loose blocks so that they may be converted from one use to the other, or may be adapted for any required shape. For plate the

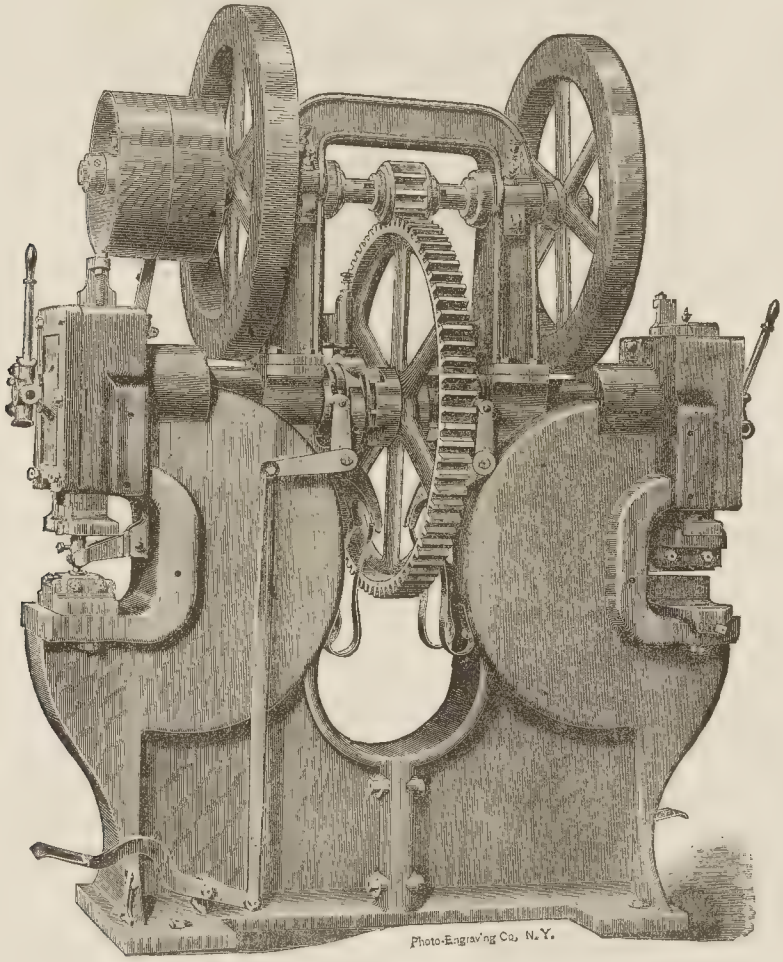


Fig. 66.

shear-blades are usually at right angles to the long axis of the frame; for bars they are parallel to it. When the plungers are guided internally the front and sides of it are left free, and proper tools can be secured to either front or sides, according to their service. By this system also the dies and blocks can be adjusted as they wear or are ground, and punches for cutting at desired intervals may be applied by adapting special blocks to hold them.

Shears for angle-iron are shown by Figs. 57 and 58, and one for bar iron by Fig. 59. The latter is arranged with its fulcrum upon an eccentric-ring, adjustable through the milled head, by which the position of the plunger at its highest point is made variable. A similar limitation may be effected by cushioning the fall of the long end of the lever. This rests upon a block of hard wood, and a thicker block permits less height of rise.

A type of light crank-punch, with connecting-rod and adjustable rise, is shown by Fig. 60. The crank-pin is

carried in an eccentric-ring, to whose face the connecting-rod is fitted. By turning this ring in the connecting-rod the effective length from crank-pin to punch-face may be varied by the eccentricity of the ring. A large size of a different design of a similar machine is shown by Fig 61.

For heavy punching of shapes from small work the type of double-connection crank-press (Figs. 62 and 63) has been introduced. The gearing is inside the hollow base and is engaged by a friction-clutch. Such a machine is capable of overcoming a resistance of 200 tons. The two connecting-rods distribute the reaction and the wear.

In the broaching-press of Fig. 64 the plunger is worked by connecting-rod from a crank upon a worm-wheel shaft. The worm turns in a pan of oil.

In the shear for flats and rounds (Fig. 65) the principle of the lever is introduced. The cutter-head is of T-shape, the center of motion being between the jaws. To the lower end of the T in the housing is attached a rod from an eccentric which is part of a worm-wheel. This wheel is driven by a worm upon the driving-shaft. This

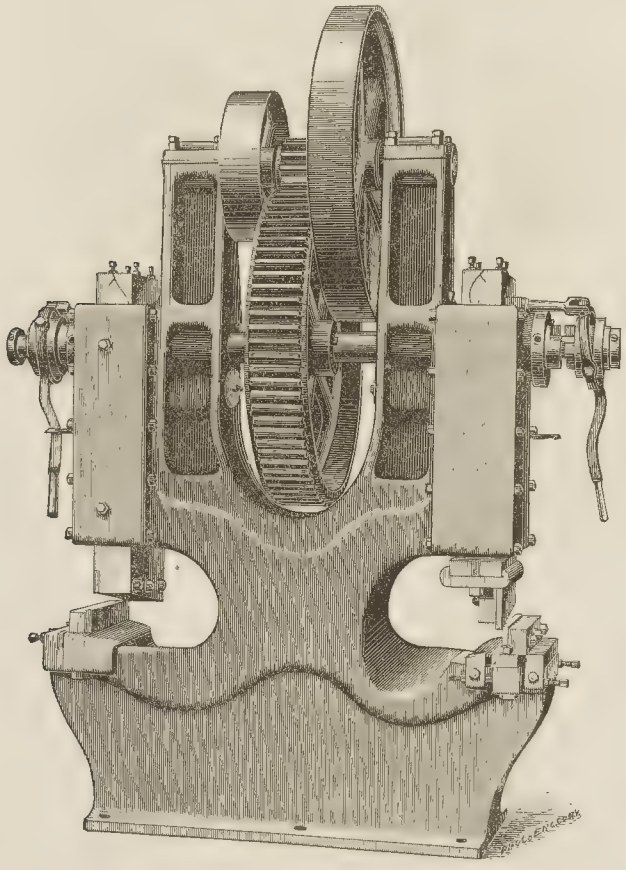


Fig. 67.

combination of screw, crank, and lever gives a compact machine of great power. By it round iron may be sheared of 3 inches diameter and flats of 1½ inches in thickness. The old styles of "alligator" shear, where the cutting-edge is on the lever itself, is not often made for large work. Its cut is weakest at the end of its stroke when the greatest length of edge is in action.

Double machines are very much used. They have the capacity each of separate machines and take less room and power than two. Figs. 66, 67, 68, 69, and 70 show types of these. Fig. 66 shows an independent stop-motion for throwing out the clutches when the plungers are up. The forked bent lever, moving the clutch, is acted upon by the bent spring to disengage the clutch whenever the latter is released. When the treadle is depressed by the foot the clutch is engaged and this spring is compressed. When the clutch is closed the cased spiral spring above the clutch forces down a vertical roller to bear against a ridge on the clutch and keep the two halves together. This ridge is broken opposite the part of the clutch corresponding to the top of the stroke, and as soon as that

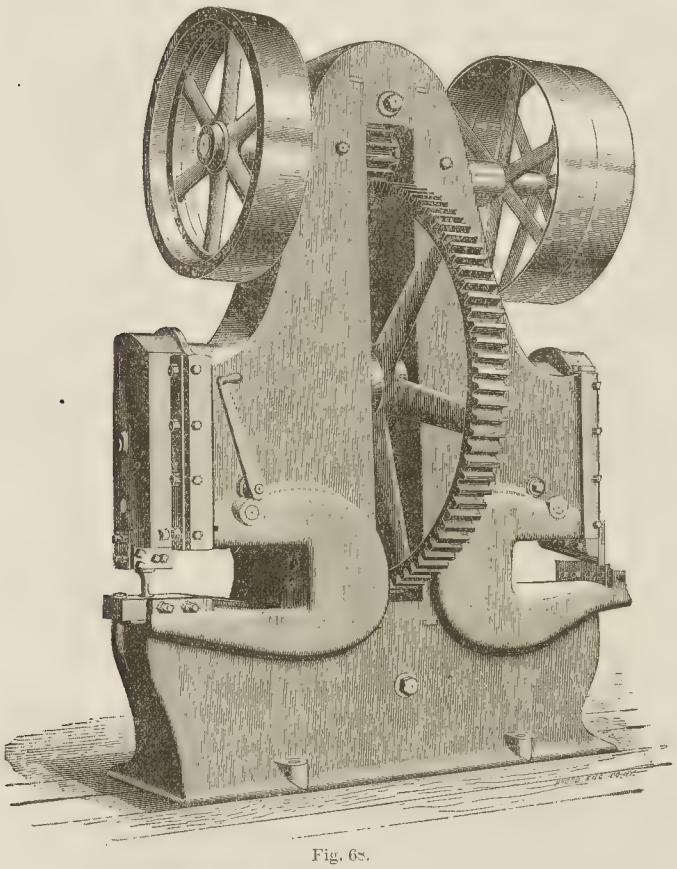


Fig. 68.

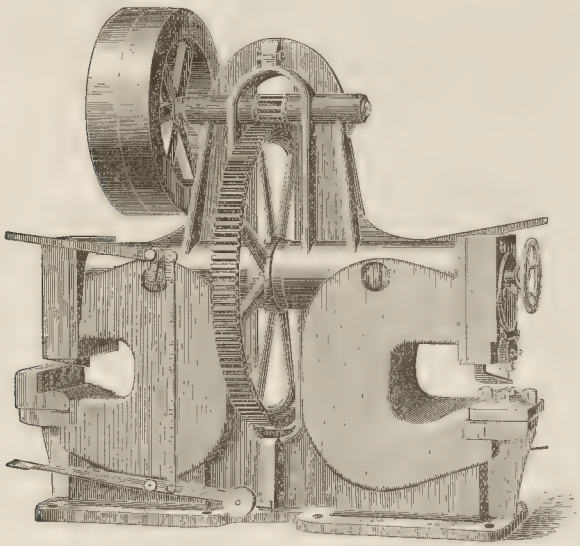


Fig. 69.

part is reached in the revolution, the treadle-spring throws out the jaws, since the vertical roller no longer holds. In Fig. 69 the fly-wheel weight is put in the belt-wheel, effecting a saving of cost of manufacture of the tool.

The same cut shows the hand-gear for bringing the punch down upon the work. These double machines are made so that either side can be worked without the other, or both at once. Often the shear side works continuously, as less time is usually required to adjust the shearing line than the circle for the punch. For reasons of compactness, these double tools are crank-machines.

For taking very long and exact cuts upon girder or ship-plate, the work should be held in place. It must also be possible to arrest a cut at a given point with accuracy. To accomplish these results the machine of Fig. 71 has been designed. The shear-blade is secured to a slide, guided vertically by the sides of the frame. Motion is given

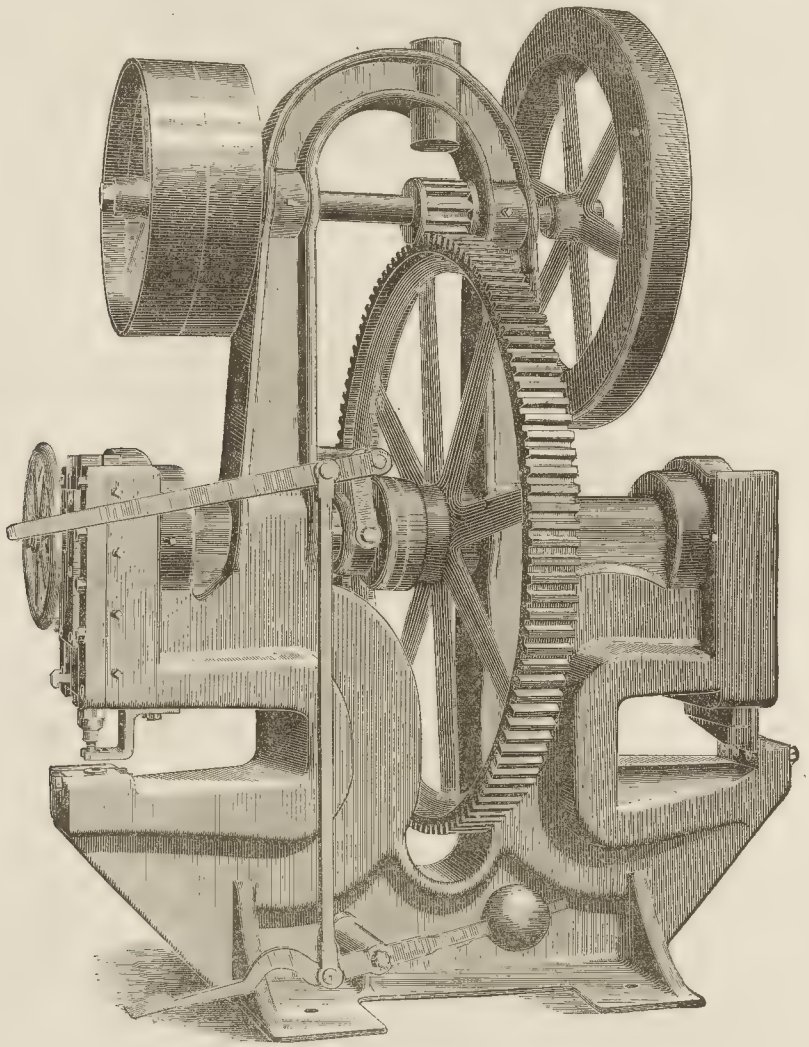


Fig. 70.

to this slide through a long solid pitman making contact-joints with the slide and the bent lever which drives it. The contact is maintained on the up-stroke by the tension-links which pass through the pitman. The driving-lever is hinged at the top of the frame, and the long end carries a toothed sector which is driven by a worm of four threads. This worm receives its motion through the pair of bevel-wheels from a belt-wheel combination of one fast and two loose pulleys with open and crossed belts. The belts can be shifted by hand, or automatically by the slide itself. The shifters can be moved by adjustable chocks. By making the overhead pulleys of different

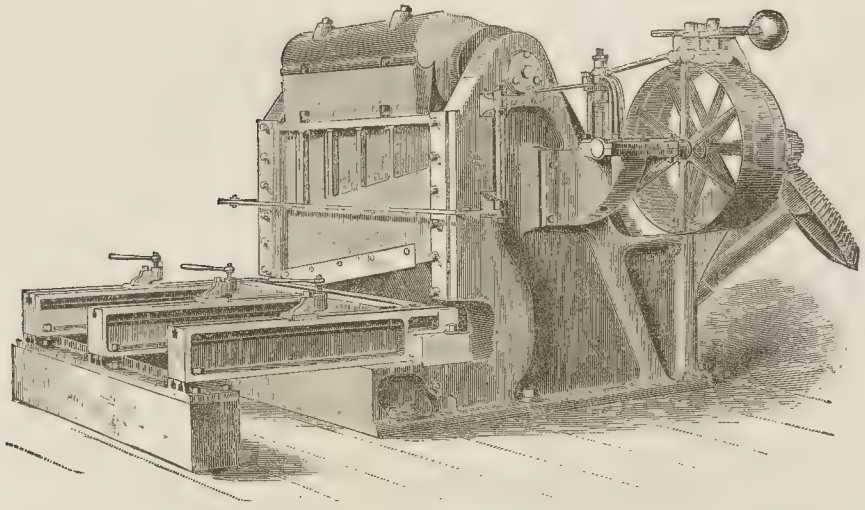


Fig. 71.

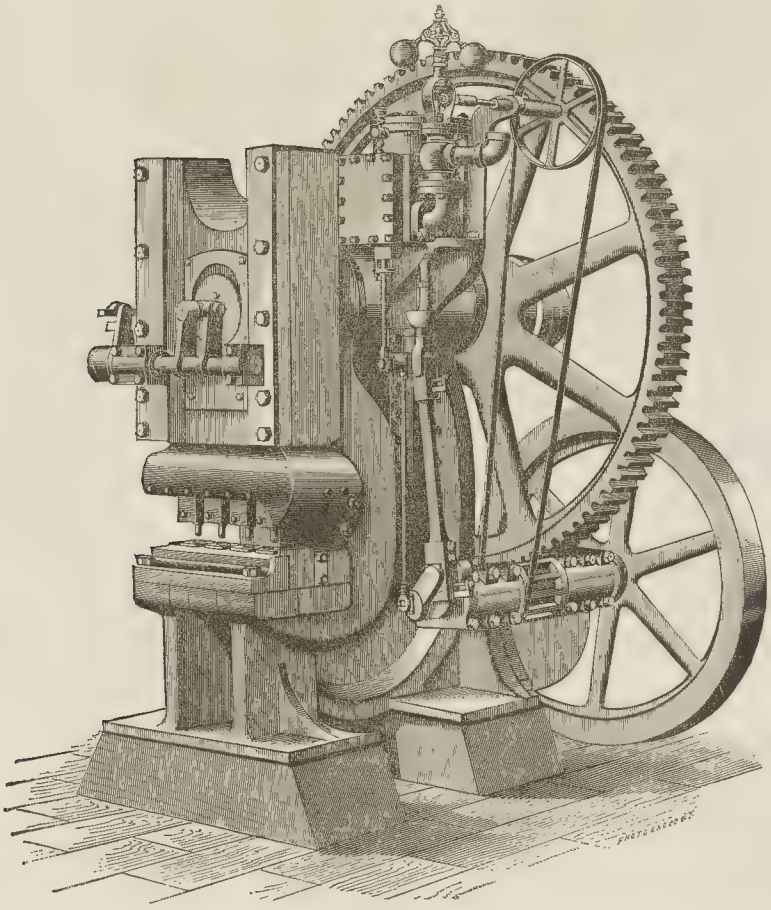


Fig. 72.

diameters, the up-stroke can be made to be more rapid than the cutting-stroke. The slide stays up until the plate is set and clamped for the next cut. The shearing-blade is here entirely under the control of the operator in every part of its stroke. Curved blades and a curved abutment may be applied with great ease for ship-work.

The wide front of the slide makes it very easy to secure special tool-blocks for multiple punching, or for punching in variable series, as in top and bottom chord webs in riveted girder-work. A combination holder may punch several spaced holes and shear the oblique end of a diagonal brace at one stroke. This can also be done on most punches with free plungers.

A crank-press of similar capacity is driven by three wrought-iron eccentrics, working upon cast-iron slide-blocks in yokes. The yokes take up wear at the pillar-bolts at the ends. The clamping-gear for the plate is automatic, being effected by a cam acting against an elbow-joint. The clutch is disengaged by a roller and side cam as in the design of Fig. 66.

Figs. 72 and 73 show two arrangements of the tools which are driven directly by steam in a cylinder which is part of themselves.

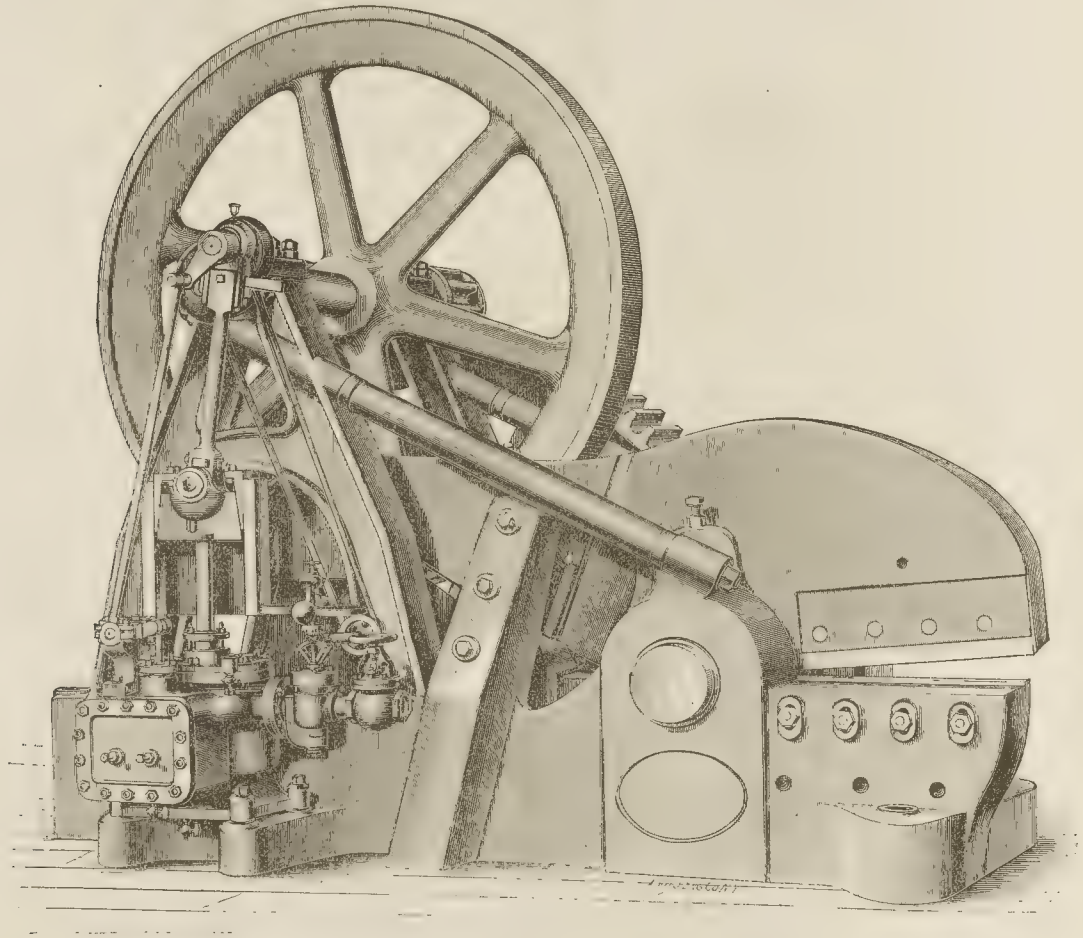


Fig. 73.

Allusion should also be made to the punches and shears which are worked directly by fluid pressure upon a piston or plunger which carries the shearing-plane at its outer end. They are not extensively in use at present, but would find their application in works which were provided with excess of hydraulic power, or in which shaft transmissions would be inconvenient.

Great economy of time in punching results from the use of spacing-tables or similar gauging devices by which the holes can be made equidistant. Without these the holes must be laid out with templet, and the plates may not be presented to the punch directly at the mark. In either case marking and adjusting to the mark take longer

than the actual perforation. These tables are carriages running transversely to the machine and arranged with a rack and different pinions, or a screw and change wheels or some other device for producing exact reproduction of standard units (Fig. 74). With such devices and multiple punches two men can cut one thousand holes per hour.

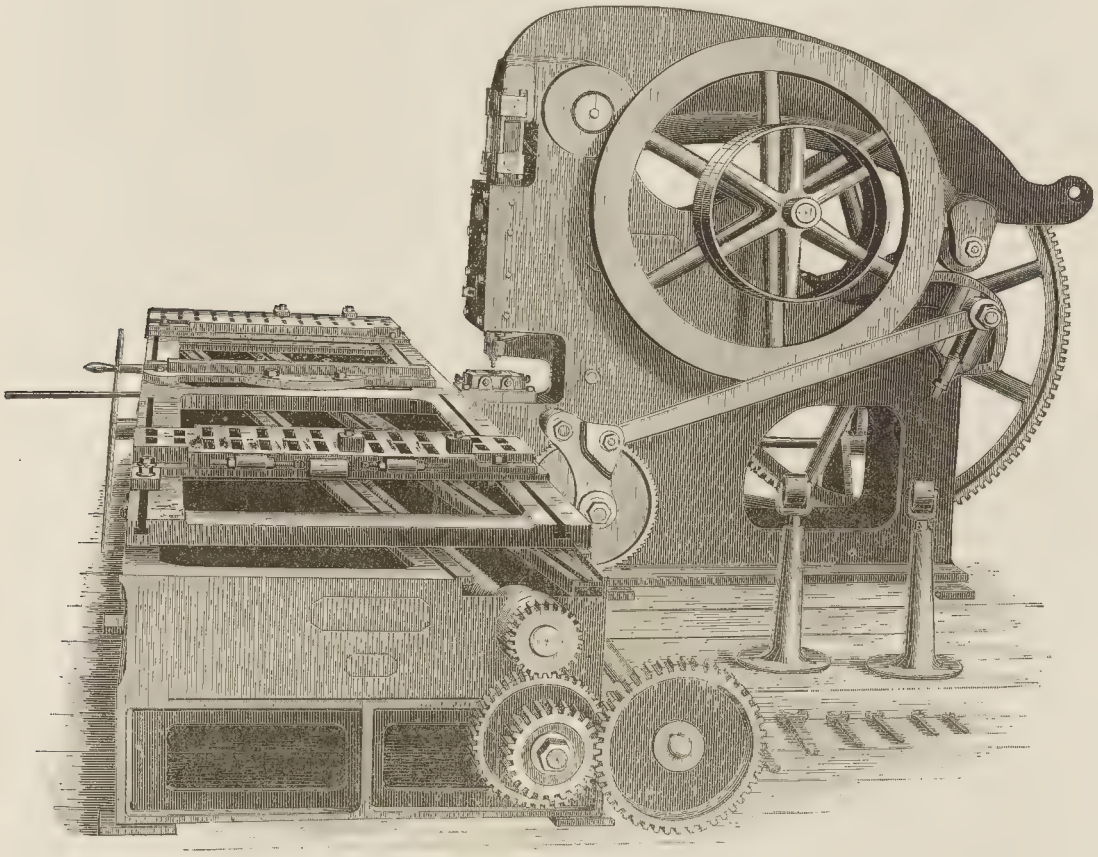


Fig. 74.

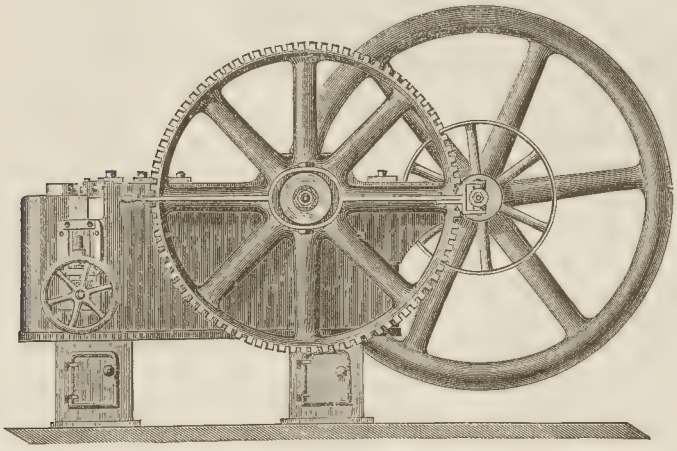


Fig. 75.

These devices can make the proper allowance for the different circumferences of outer and inner sheets in cylindrical boilers. Horizontal punches for flanged boiler-heads or fire-boxes or for angle- or tee-iron are also in use. They are called for because of the special limitations imposed by some shapes. Fig. 75 illustrates one type of such tools.

In limited use is also a type of shear for boiler-plate, the plane of whose stroke is oblique to the horizon. The idea of this is to shear the edge of the plate upon a bevel and remove the necessity of edge-planers to make ready the sheet for caulking.

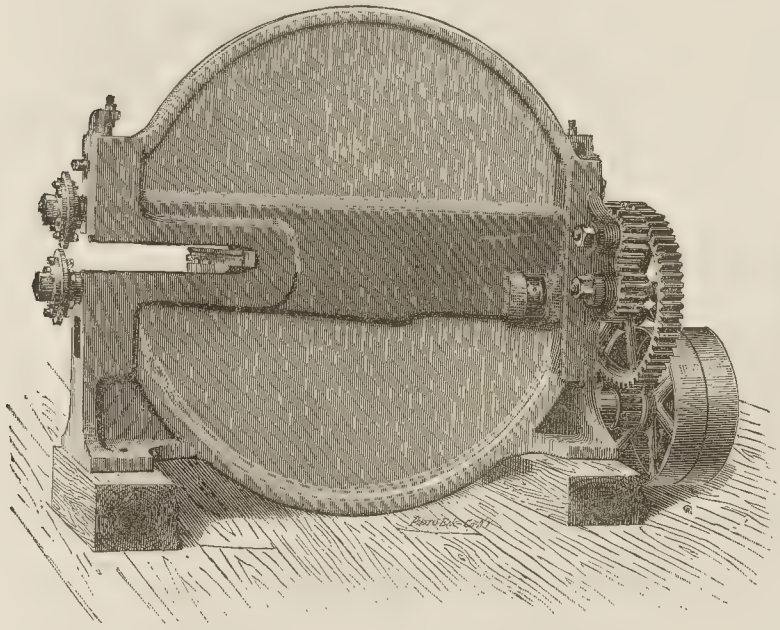


Fig. 76.

In the class of rotary shears but few large examples are seen. Two disks of steel slightly beveled and over-lapping are driven by power, and the plate to be sheared is fed against their point of contact. The disks can be brought together as they wear, both being driven by expansion gear linked to the spindles of the cutters, and can be set axially for different spaces at the cutting-point. They meet their chief application for light iron or other sheet-metal work, since they will cut a curved line. The disadvantage for heavier plate is that the knives grow jagged and chatter and mar the work. They are not very extensively in use at this date.

Fig. 76 gives an illustration of one design for large work, up to $\frac{3}{8}$ of an inch thick.

Punches and shearing-presses are extensively used in drop-forging work for trimming or broaching the work after leaving the dies. They are also used to produce a cold-press finish upon pieces which would otherwise have to be milled. The double-connection presses are used for this class of work. In the sheet-metal presses, and in those used for the manufacture of drawn goods, shearing is also done, but these tools are beyond the province of this discussion. These tools belong either to the crank class or to a special class of roller-cam presses.

§ 15.

C.—TOOLS ACTING BY PARING.

To this class belongs the majority of the tools of the finishing- or fitting-shop. It includes all those in which the desired figure is produced at the working point by the scraping or cutting action of a wedge-pointed tool. Since they act upon the cold metal and remove relatively small amounts of material in the cut, these tools are much better adapted for working to exact dimensions than those acting by compression or shearing. They can also produce an ornamental finish upon the material which they shape. These features adapt them for the needs of the shop from which the completed work is to be delivered.

Paring-tools belong to two classes. The first includes those in which the relative motion of tool and work is circular or spiral. These can only produce surfaces of revolution, and include lathes, drills, and boring-machines. The second class includes those in which the relative motion of tool and work is rectilinear. These will produce plain surfaces by planers, shapers, and slotters, and also curved surfaces made up of straight line elements by the two latter tools.

The greater part of revolving machinery is made up of surfaces of revolution. The cylinder of these is by far the most important. The lathe will therefore be discussed first.

§ 16.

HORIZONTAL ENGINE LATHES.

The essential parts of a lathe are the bed, the head-stock, the tail-stock, and the arrangements for holding or supporting the tool. This latter device is called the slide-rest or carriage.

It is the primary function of a lathe to produce a truly cylindrical surface, with plain heads perpendicular to the axis, upon the rough material presented to it. The motion of the point of the tool must therefore be truly parallel to the axis of the tool; this latter must be a true straight line, and the secondary motion of the tool must always be at right angles to this line.

The first condition must therefore be stiffness in the bed of the tool. Under the strain of the cut it must not bend downward nor yield laterally. The bed is usually of cast iron, made of two girders of approximate I-section, whose flanges shall give the necessary vertical strength. The newer tools are built with much greater depth of bed than the earlier forms had. To secure lateral stiffness, the two girders front and rear are connected by interior cross-girts about 2 feet apart. These bind the two sides together, and are put near enough to each other to avoid any spring between them. Small lathes are mounted upon legs at sufficient intervals; the lathes of larger swing must be bedded upon a foundation upon which the bed rests directly.

Upon the top of this bed will be the guiding lines for the movable tail-stock and tool-carriage. The finished upper surface of a lathe-bed is called its shears. There are two types of practice with reference to the form of track upon which the sliding parts shall move. In one type the shears are finished off flat, and in the other there are four parallel tracks upon the shear, of inverted V-form, truncated on top.

The advantages of the flat-top shear are its extended bearing surface on the bottom of the carriage and the ease with which the true flat surface may be produced. The large surface reduces the pressure per unit of area, insuring lubrication, and therefore retarding the wear of the sliding surfaces. If hollow places are worn in the shears, the tool-point will fall at those points, producing untruth in the cylinder which is being cut.

The objections to the flat shear are that the tail-stock must move easily in the opening between the shears, that it may be adjusted for work of differing length. For this ease of motion some play must be left between the two sides of the bed and the guiding surfaces of the tail-stock. This play will be enough to vitiate the truth of the cylinders cut by the lathe. Its effect has been avoided by one designer, whose lathes have a V-track upon the under side of one shear. The clamping device fits over this V from below, and when the tail-stock is clamped it is

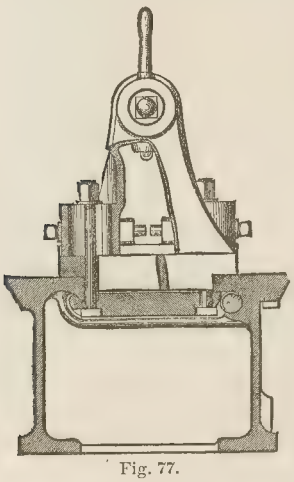


Fig. 77.

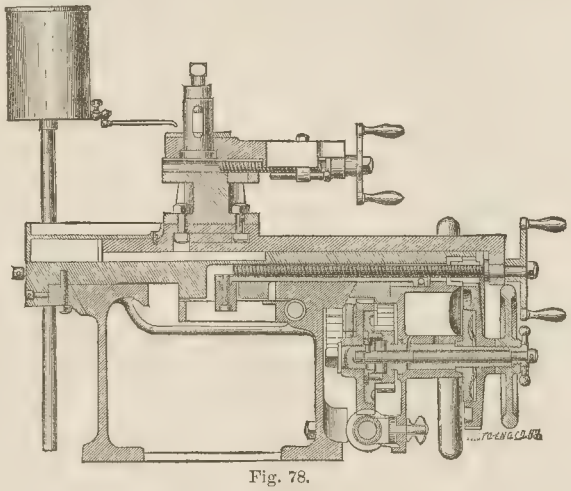


Fig. 78.

certain to be drawn always into the same relation with this V, and the axis of the lathe will be always in one line (Fig. 77). In other designs the stock is kept up to one side by adjustable brass taper gibs, reducing the lost motion to a minimum. The guiding of the tail-stock by the inner edges of the shears is practically universal in the flat shear designs. The carriage or saddle carrying the tool-holder will be guided upon the outer edges (Fig. 78). Otherwise, the wear on the surfaces nearest to the head being the greatest, the untruth of the axis would be increased by the lateral wear due to the carriage-motion.

A second objection to the flat shear is that it opposes its strongest resistance to the vertical components of the strain on the tool-post, while the horizontal components are only taken up by gibs. In turning large work upon a

small lathe, where the point of the tool is over the shear, the vertical components will be the greatest. Upon a large lathe also, where the shears will be wide and the carriage and attachments heavy relatively to the strain of the cut, the vertical components will be in excess. But in a lathe cutting work of small diameter, whether facing, boring, or turning, the strain on the tool-post is oblique, passing downward at an angle from the center which varies with the swing of the lathe, and will average perhaps 30°. This strain tends to force the tool downward and outward. The downward strain is resisted by the broad shear; the lateral strain comes upon the gib at the rear only (Fig. 78). This latter strain is not opposed by surfaces at right angles to it nor by surfaces of large area. The freedom for sliding upon the fitted surfaces must also be in this lateral direction, which at the same time is the direction in which untruth will produce the greatest effect to mar the work.

The further objections which have been urged against the flat shear that they make it harder to move the carriage, and that chips from the work get ground into the ways, may be dismissed with a word. The ways will not be clogged when the tool is taken care of as it should be; and a new form of flat shear with a lower step for the tail-stock motion is an effectual preventive of the latter difficulty, even if it were a real one, with shears in one plane only.

The advantages of the V- or track-shears consist, first, in its opposing a resistance normal to the oblique pressure due to a cut on a small cylinder. Upon the top of the bed are four raised rails, of inverted V-form, truncated on top. These V's are of varying angle, around 60° as a mean. The sides of the V's which face the

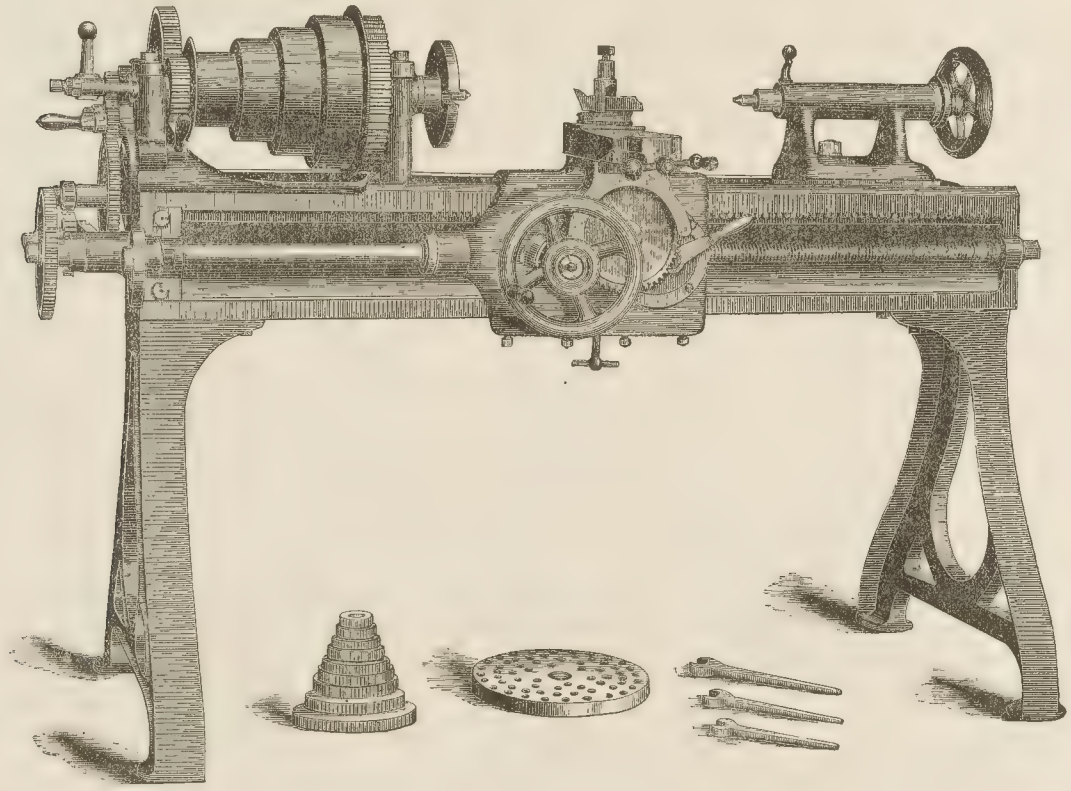


Fig. 79.

back of the tool on each shear are about normal to a strain which presses down obliquely at an angle of about 30°. In some cases of large lathes the angle of the track is about 90°; in others it is 75°. The carriage is carried upon the outer pair of V's, resting upon them in grooves planed in its lower side. It is kept from rising by gibs under the flange of the bed-top, and its own weight secures all the freedom required for ease of motion, without lateral play. The tail-stock travels by similar grooves upon the inner pair of V's, thus securing at all times a perfect alignment with the head-stock. Moreover, the clamping of the tail-stock upon the V's holds the frame from spreading, and acts as a rigid cross-stay where the strain of the dead-center comes. Its freedom of motion is secured by its vertical yielding only. When the tool is at work, therefore, is the time when all its parts come most exactly into line, provided the shear-tracks are perfectly parallel.

Against the V-shears stand the diminished surface for wear by vertical strains, the danger to them from blows, the difficulty of keeping them lubricated, and the expense of accurately fitting them to parallelism and to the grooves in carriage and poppet-heads.

The V-shear is the characteristic American type. It is preferred among all the New England manufacturers, where the tools are built for general work and for jobbing, where small diameters will predominate. Around Philadelphia the flat shear is popular, where the tools are built more for large and heavy work, where the downward pressure will be in excess. For axle or shafting lathes and others, where one diameter is to be prevalent, the shears may be so proportioned as to bring the bulk of the strain vertical, and the flat shear will then be preferable. For large tools in best practice, the moving parts will travel upon three shears instead of upon two only (Fig. 119). This may reduce the swing of the tool slightly, but the gain in stiffness more than compensates for the loss.

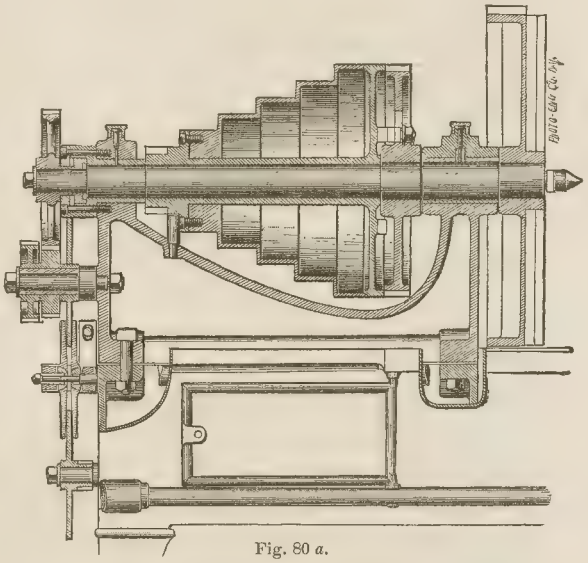


Fig. 80 *a*.

One form carries the slide-rest upon the front of the bed only (Fig. 79). This gives large swing over the shears. The carriage does not wear the track of the tail-stock.

Upon the bed of the lathe will be the head-stock and tail-stock, the former carrying the rotating or live center, and the latter the stationary or dead-center. The head-stock will be bolted to the bed securely. The tail-stock must slide along the bed to accommodate work of differing lengths, and should clamp securely fast to the bed with the center in the true axis of the tool. For lathes of small swing Fig. 80 *a* illustrates the general construction of the head-stock in section and in plan. The essential feature of the head-stock is the live-spindle. This is made of steel up to certain sizes, hardened and ground true. Upon the truth of this spindle depends the truth of all work done in the lathes. Any errors in it will repeat themselves, especially in work chucked to the face-plate. In small lathes this spindle turns in hardened steel split boxes. For the larger sizes composition boxes, and cast-iron boxes with babbitted pockets, divide the manufacturers about equally. Many would prefer cast iron alone if they could always insure lubrication. The front journal is always made cylindrical in best practice. Conical journals are apt to "seize" from some variation in temperature and will become cut out of true. Older practice had a collar upon each side of the journal. Newer practice leaves off the outer collar, and the most advanced designers leave off both shoulders and control the end play of the spindle from the outer end. In this system the front or inner journal controls the sidling or lift of the spindle only, and any changes of temperature cannot impair the fit or cause lost motion endwise. To take up the thrust of the tool against the work when facing or when feeding heavily toward the head it is necessary to have some sort of step at the outer end of the spindle. Where the single-shoulder system is in use the rear end turns in a cylindrical box, which is closed at the outer end. Through this closed end passes a hardened steel screw whose axis coincides with that of the spindle. This tail-screw either bears directly against the hardened end of the spindle or else through a washer. The washer is sometimes a disk of hardened ground steel, but in most frequent practice a washer of rawhide is employed. This causes less difficulty from the danger of cutting if it gets dry by accident, and is increasingly popular. The difficulty is the lack of uniformity of the hide. The tail-screw is secured from working loose by a jam-nut against the box, and any degree of closeness of fit longitudinally is obtainable. One designer uses a washer of vulcanized paper fiber, and one uses composition. There are advantages connected with

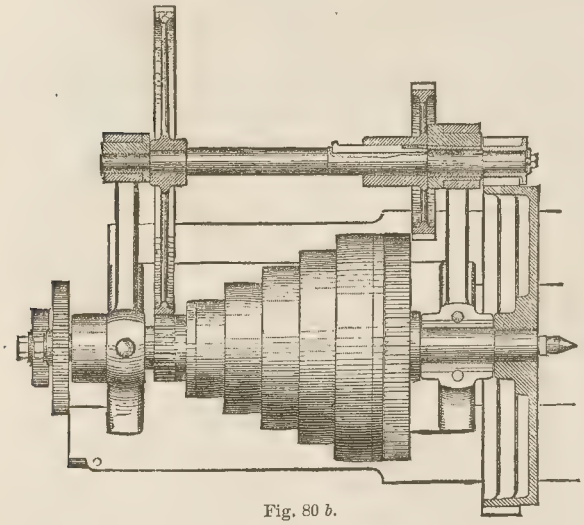


Fig. 80 *b*.

the practice of confining the spindle from end motion in both directions from the tail end. A type of such designs is shown by Fig. 80 *b*. Near the end of the spindle is secured a hardened steel ring or collar, which is ground true and runs between similar washers, from which lost motion can be taken up. When kept well oiled by keeping an oil-cellar full these disks run without liability to stick or jam.

To insure that a lathe-spindle shall always run true, even after wear has begun, beside taking up the end play, is the object of the spindle-journal invented by one of the New England builders. The box is a split cylinder of gun-metal, with conical screw-threads cut on the outside at the ends. Two cheese-nuts fit upon these screws, and by turning them down the box is closed up concentrically upon the journal. A wooden pin prevents the nuts from closing the splits too closely. At the rear box, beside this arrangement, is a bearing-step for motion in one direction, and a pair of jam-nuts bearing against a washer prevent motion in the other direction. The chief point with regard to these thrust bearings is that they have sufficient area. Otherwise they will be apt to wear into rings and cut the surfaces. One designer using steel disks makes them a little smaller than the cell in which they lie. They will turn freely, and yet, being eccentric to the spindle, they must be worn flat uniformly, and will tend to bring up oil from the bottom of the cell upon the step. The advantage of discarding the prevalent step-screw is that the pinion for the feed-gear for the carriage can be put directly upon the end of the spindle. Otherwise this pinion must be inside the head casting, and the latter must be perforated to allow an idle spindle to pass through it, with gears outside and inside. This weakens the head and prolongs the span of the spindle between journals. The alternative way, retaining the step-screw, is to mount the latter upon a separate cross-piece at the tail, supported upon pillar-studs tapped into the end of the head. The Pond box (Fig. 81) permits the spindle to pass through freely, since the thrust is taken up on a steel ring shrunk on the spindle. A hollow steel sleeve flanged at the inner end screws against this ring through the end of the box. The box is hollowed into a chamber around the ring and flange, which is filled with oil up to the horizontal diameter. For the largest sizes of lathes, where the spindle will be massive enough to be made of cast iron, the thrust will be taken up by the collars upon it. The faces of the boxes will often be recessed and babbitted in these designs. One designer of light lathes (Fig. 82) uses a cylindrical box externally, so that the box may be replaced when worn, without replaning the head, to bring the spindle in the center. The boxes are split, and a conical-pointed screw in the crack prevents cramping on the journals.

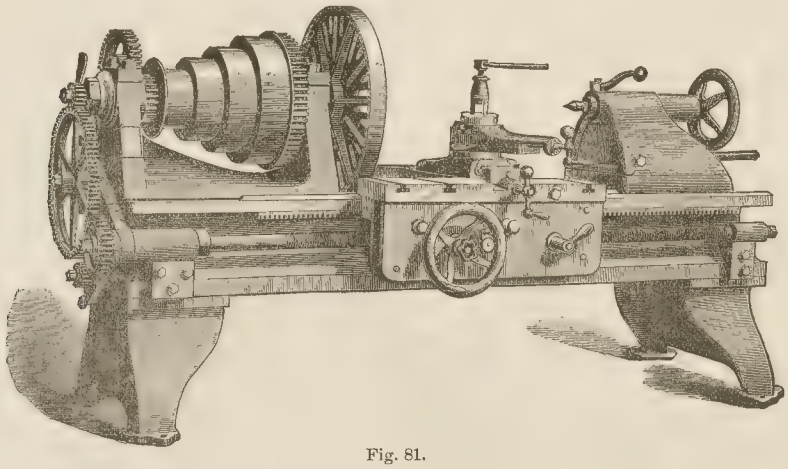


Fig. 81.

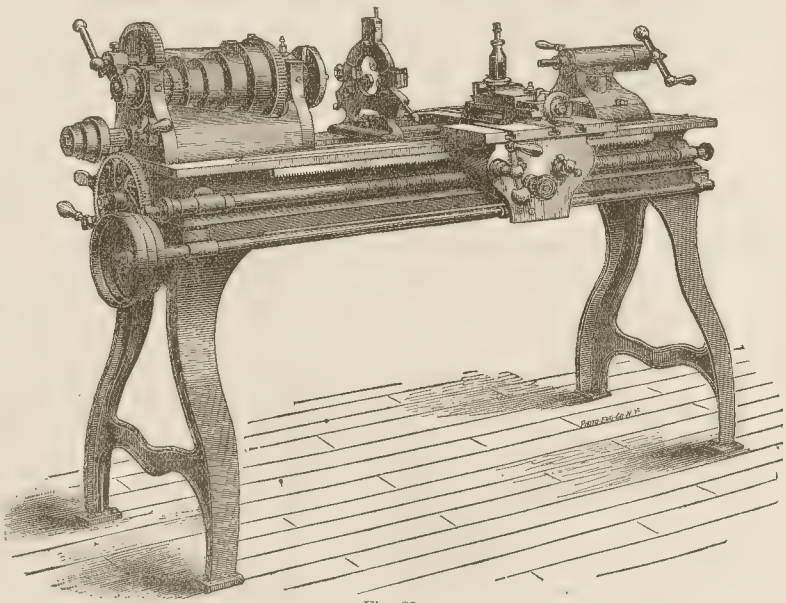


Fig. 82.

The shape of the casting in which the boxes for the spindle are supported will be seen from the various cuts. The top surface curves upward toward the tail, giving effective depth to resist the strains at that part. In one design the hollow underneath the casting is braced by stiffening ribs. The differences required for the lathes of larger swing are solely due to their larger size. The aim of the recent changes of design has been to secure the greatest stiffness and strength against the strains to which the head is exposed.

Upon the live-spindle turns freely the nest of cone-pulleys. This is a series of belt-wheels of different diameters, made necessary by the variety of work to be done upon the tool. The cutting-edge of the tool can act at different speeds upon brass, cast iron, wrought iron, and steel, and a given speed must not be exceeded upon the circumference of cylinders of very different diameters. This variation is most easily accomplished by the use of two nests of cone-pulleys, one on the counter-shaft and the other on the tool. The two nests are complementary, with the sum of the diameters of each pair in the series equal to a constant quantity. The same belt can be used on all, but it

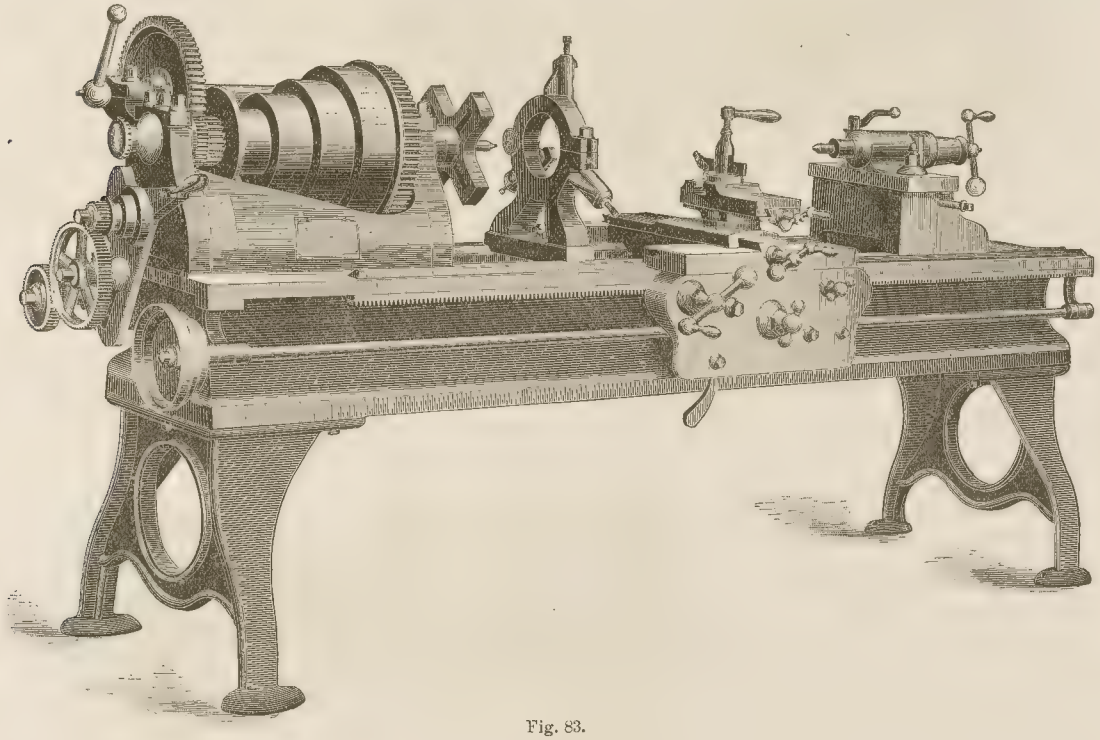


Fig. 83.

will run at different speeds, and therefore produce different speeds of rotation of the work. There are usually four pulleys in the cone. Three only are put on the small sizes, while the very large have five, six, or seven. The faces of the pulleys are most frequently flat; those of a few builders are made crowning. The pulleys are made in one hollow casting, with a long sleeve for the spindle to pass through. The end of the sleeve in larger cones is braced to the large pulley by a spider cast with the cone. For ease of fitting, the sleeve is often cut away in the middle of its length and bears on the spindle at its ends only. The pulleys are sometimes turned on the inside, to insure a perfect balance and smooth running. At the small end of the cone a flange is often put to prevent the belt from running off into the gears. If no flange is used, a guide-pin may be put below, into the casting, to serve the same purpose.

Beyond the flange is a small pinion, either cast as part of the cone or secured to it by screws. This pinion is to drive the "back-gear", or "double-gear", as it is called. This consists of a shaft holding a large and a small gear-wheel, which may carry the motion around the cone-pulleys to a large gear in front of them. This large gear is secured to the live spindle. It will be seen that when the small gear on the cone-pulley drives the large gear on the back-gear shaft, the latter will move at a speed much lower than that due to the cone-pulleys. When again this motion is further reduced, because a small pinion on the back-gear shaft drives the large gear on the spindle, the speed of the work will have been very much lessened. The back-gear usually reduces the speed of the spindle to one-sixth or one-tenth of that due to the cone-pulleys. The back-gear shaft is hollow, and turns upon an interior spindle which passes through it. At each end of this spindle an eccentric-pin is turned, which fits into bearings in

the head-casting. It will be seen that if the spindle be turned through 180° it will move the back-gear shaft bodily sidewise through a distance equal to twice the eccentricity. This distance need only be made a little more than the depth of the gear-teeth to furnish a most simple means of engaging and disengaging the shaft with its two gears. Some designers make the eccentricity larger, so as to require less angular motion of the back-gear lever to engage the wheels. The difficulty with this system is that the gear will throw itself out if the bearings are an easy fit. The strain of the gear is a lifting push, and if it takes the eccentrics at a favorable angle it will turn them. Most builders put the eccentric-pins so as to be on the line of centers when in gear. One maker turns the pins a little farther (Fig. 83), so that the strain which tends to separate the gear is opposed by the lower stop. Such an arrangement could not possibly throw out. The engaging-lever on large lathes is often doubled (Fig. 84). Some largest lathes, where the double-gear will be always in use except when polishing, have the composition boxes movable on their seats, so that they can be slipped sidewise, and are then held by a key.

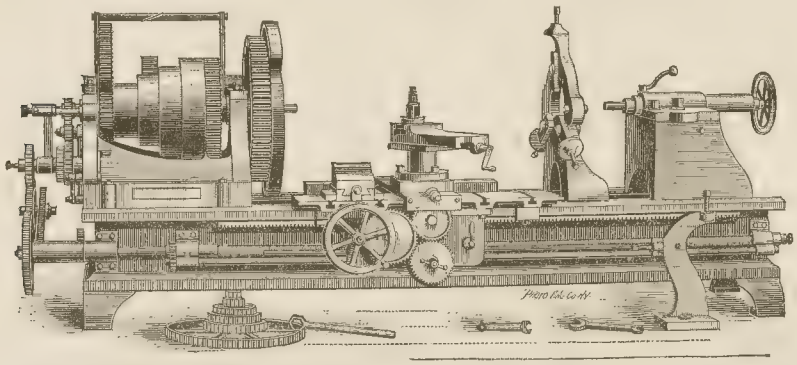


Fig. 84.

Many of the larger lathes are also triple-geared. Beside this back-gear combination, there are often teeth cut upon a circle larger in diameter than the gear which is fast to the spindle. These teeth will be upon the back of the face-plate, and will be driven from a smaller gear on the back-gear shaft prolonged, or else indirectly from it through idle gears (Fig. 85). In these large lathes the face-plate is never removed, since it is inconveniently heavy, and the work can very readily be driven by it. Where the face-plate is driven directly, it is necessary that both pinions on the back-gear shaft should be movable lengthwise on their splines, since they both must not be in gear at once with wheels of different diameters fast to the spindle. Where the power is transmitted through idle wheels, the slip-gear may be the one on the back-gear shaft only. It may slip out of gear with the spindle-wheel and into gear with the face-plate train, with an interval between their planes from which neither will be driven. Sometimes the whole back-gear shaft slides lengthwise and is held in place by a pin, taking into grooves cut in the shaft. The idle-wheel system is specially desirable where the face-plate teeth would come on its periphery. It is much better to make the face-plate teeth internal upon an annular flange in this case (Fig. 85), both for cleanliness, for safety, and to prevent interference with the chucking of large flat work. In many large lathes the cone-pulley spindle drives internal gear on the face-plate through an ordinary back-gear combination. The cone-pulleys are not on the live-spindle in this case (Fig. 86). Where the face-plate is larger than the gear-circle desired the teeth on the latter may be external. Some lathes for special classes of work are driven directly from a pinion on a splined shaft to teeth on the periphery of the face-plate.

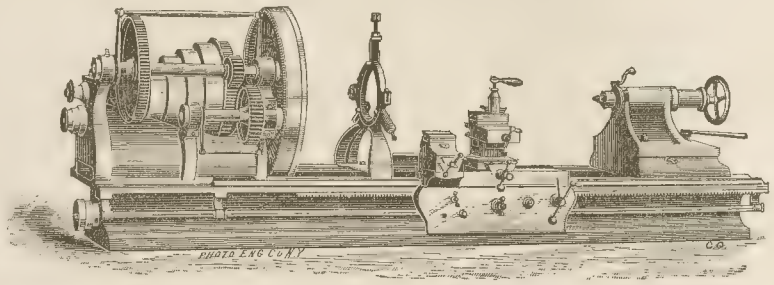


Fig. 85.

When the lathe is to be driven at speed for polishing or the like the back-gear shaft will be turned out and the cone-pulley will be clamped to the large gear fast to the spindle. This clamping is effected by a bolt passing through a slot in the plate of the fast gear-wheel. This bolt will cause a short slide to catch between jaws upon the inside of the cone-pulley, so that when the bolt is tightened the cone-pulley and gear become as one; or they may be clamped together by a regular friction device. For some special classes of manufacture, where the work, for example, is to be chucked, faced, polished, and drilled centrally, the back-gears and two speed-changes are all controlled by friction-clutches, so that the speeds may be changed without loss of time to stop the tool and shift belts or loosen nuts. One firm put several lathes upon the market in which the back-gear wheels were made with

helical teeth. The object of this was to cause more even working of the spindle and to lessen the vibrations of the work when driven through gears. It was not found to compensate for the trouble in shaping the teeth, and has been abandoned.

Upon the end of the spindle is secured the face-plate. This is simply a disk of cast iron, with radial slots in it, through which bolts and pillars can be passed to secure work to it. The front face of it must be a true plane and perpendicular to the axis of the lathe and of the spindle. It should also be balanced. It is usually screwed upon the end of the spindle, finding a true bearing at the end of the thread. As the lathe always turns in the direction opposite to that of the hands of a watch to one facing the inner end of the spindle, the resistance to the

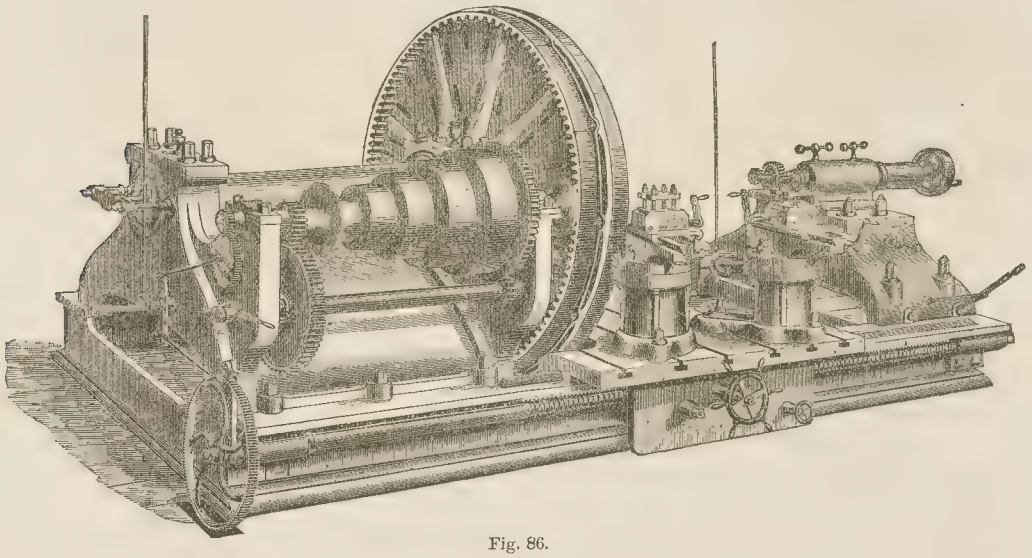


Fig. 86.

cut only screws the plate tighter when threaded on by a right-hand screw. Sometimes, besides the short slots, there are three or four long slots carrying jaws which can be moved upon the plate by screws in the slots. These serve to secure work to the plate, which will then be called a chuck-plate. For rod-work, screw-cutting, and the like, the face-plate is often replaced by a drive-plate, a flat disk with a slot cut on it along a radius to hold the tail of the dogs or drivers (Fig. 82). The four-armed spider is also used for dogged work (Fig. 83). A universal chuck can also be screwed on the end of the spindle when required. Usually the spindle is threaded to its end. In some cases the thread is made much shorter and the end of the spindle made to fit the plate or chucks upon a cylindrical surface left on it beyond the screw. This makes the adjustment of the plate more rapid and lessens the danger of battering the shears in cases where the heavy plate is only released from the screw when it is able to drop.

In the inner end of the spindle is bored the taper hole for the live-center. This, of course, must be truly central, and is made tapering to insure a tight fit at all times and truly in line. The taper is quite long, in order to secure ample bearing for the center when in place. The spindle is often made hollow in small lathes to accommodate lengths of rod, and also to permit the introduction of a rod through the tail-screw by which the center might be driven out when chucks were to be used. Where the centers were made of a long cone fit joined to the short cone center point by a short cylinder this device was very convenient. The newer centers are made with a squared surface outside the fit upon which a wrench can take hold to loosen them. The centers themselves are made of steel hardened at the point and ground truly conical in place. The angle of the cone varies from 60° to about 75°. The former is in many places more general. It is the apex of this cone which determines the axis of the tool, since all surfaces of revolution will turn around the line drawn between the points of the live- and the dead-center as an axis. It is necessary, therefore, not only that both cone centers should themselves be perfectly true, but that both apexes of the cones should remain in the intersection of the same horizontal and vertical planes in whatever part of the bed of the lathe the former may be.

It is the object of the tail-stock to insure the permanence of this axis of the lathe, and to permit considerable variations in its length. There will be a rough adjustment for length of work by hand, and a finer adjustment by a screw, while both must be clamped from moving out of adjustment when in place. The tail-stock is guided from lateral motion by the inner edges of a flat shear, or by the inner tracks of the V-shear.

When at the right position on the bed it is clamped in place by a cross-bearer, which is brought up against the under side of the bed. This clamp may be tightened by one screw from below, by an eccentric-cam, turned by a lever (Fig. 89), or by two or more bolts, one at each side of the casting. On the larger lathes there will be more than one clamp, and therefore more than one pair of clamping-bolts. The eccentric is adapted for medium and small sizes only. The screw arrangement is the most general. Upon the top of the movable stock is the finer screw adjustment for length. This consists of a spindle, cylindrical on small lathes and square upon some large ones, which has a long bearing (Fig. 87). This spindle may be moved in and out from the tail-stock by a screw which is turned by a hand-wheel or ball-handle from the extreme left end. This screw is usually cut with a left thread, so that the spindle may be protruded by an instinctive "screwing-in" motion. When the end of the center enters the drilled hole in the work, the spindle must be clamped to prevent the center from turning out. It is therefore necessary that the spindle shall move in the axis of the lathe independent of the tail-stock, and also the clamp must be such as not to throw the end of the center out of line. There are three types of clamps for the spindle. One form draws up a ring or forces a set-screw or other frictional device upon the center of the spindle from above (Fig. 88). The second clamps the outer end of the spindle by a screw which tightens a collar split upon one side. This collar is often a projecting part of the long bearing (Fig. 89). The third type (Figs. 90 and 87) uses a split sleeve tightened upon the spindle by a conical muff. The muff is drawn upon the sleeve by a screw when a partial turn is given to it. This latter system has the advantage that under abuse it will not be so likely to spring the spindle out of line, either up or down. The casing containing the long bearing for the spindle is cast solid. In the earlier forms, the cap which guides the screw had to be screwed on by a flange. The spindle is kept from turning by a spline.

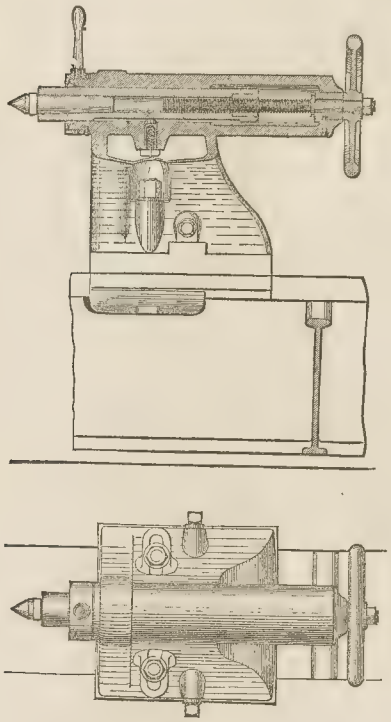


Fig. 87.

The tail-stock in universal practice is made in two parts. These are planed to fit together upon transverse ways, and secured by clamping-bolts or by set-screws.

The object of this arrangement is two-fold. It is desirable to have this lateral adjustment of the dead-center, because in boring the casing for the spindle in the first instance it is hard to get the lateral accuracy of the boring-bar relative to the shear-guides. The vertical adjustment is easy. Since it is desirable to have a little lateral adjustment for the dead-center when in place on the shears, this lateral motion can be easily made larger, and the lathe will then turn conical surfaces as well as cylindrical. Such tail-stocks are called "set-over tail-stocks", and have been hitherto almost universal. Advanced practice of to-day, however, prefers the use of an attachment for turning tapers which controls the motion of the tool. This system not only avoids the difficulty of readjusting the rear spindle after every taper, but also permits the boring of taper holes without a compound rest. When taper attachments are used, the tail-stock has only sufficient motion for adjustment. The older standard form of tail-stock is shown by Fig. 91; the newer shape is that of Fig. 81. Very often a small oil-cup is cast in the spindle-casing, from which the lubricant can very easily be put upon the stationary center. The largest tail-stocks are too heavy to be moved directly by hand, so that a small pinion is made to engage in a rack at the side of the bed, and the squared end of its vertical axis will take the end of a long lever. The rotation of the pinion drags the heavy casting upon the shears. On some of the largest lathes also the tail-spindle has power-feed for boring. This type will be illustrated by Fig. 92 and further in advance.

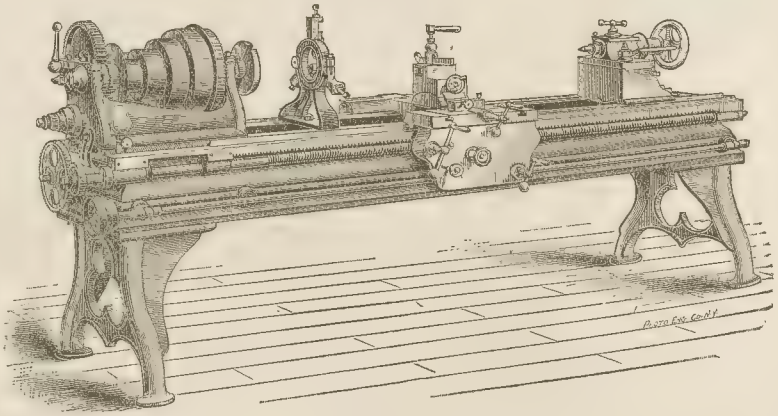


Fig. 88.

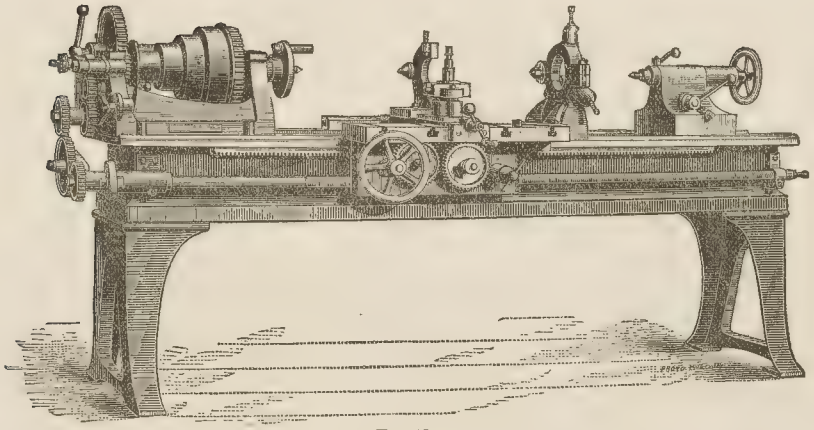


Fig. 89.

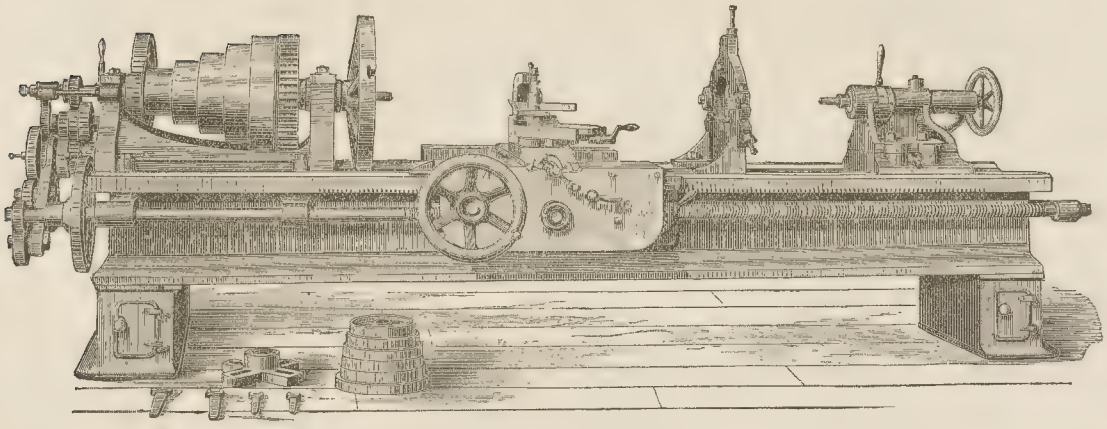


Fig. 90.

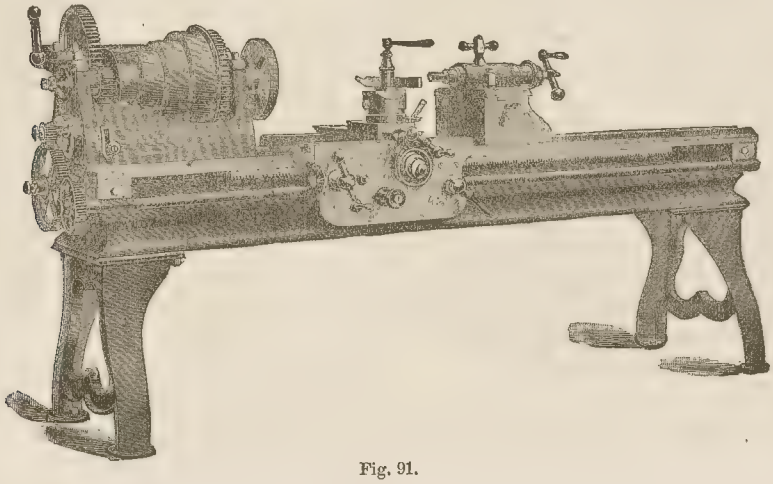


Fig. 91.

The line between the centers being thus made exactly true, it remains to give to the tool-point a motion which shall be truly parallel to that axis, and also one at true right angles to that axis. The motion of the tool parallel to the line of centers must also always be in the same plane with that line. The tool will therefore be rigidly held in a

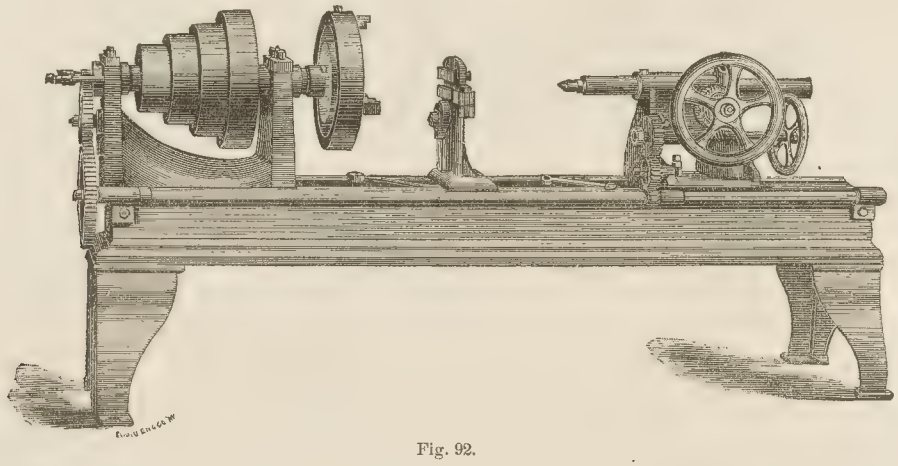


Fig. 92.

tool-post, supported upon a guided carriage. This carriage must receive the two motions at right angles to each other, each motion being independent of the other. The lower part of the carriage will span the opening between the two sides of the bed, so as to be guided by its extreme ends. In the flat shears the tendency to twist the carriage is resisted by the outer surfaces of the shears. These incline inward, and adjustable gibs are fitted against these inclines front and rear, which also keep the rear end of the carriage from lifting under the strain of the cut. In the V shear system the carriage rests upon the outer rail of each shear, and is thus kept from lateral motion. Flat gibs under the square edges of the shears resist what little tendency there may be to cause the saddle to lift. In both cases the bearing surfaces of the carriage are made much longer than is necessary, simply to support the cross-rail or saddle. The plan of the whole would be usually a square, in which the sides were broken away to enable the saddle to come close to the head- and tail-stock. The necessity for these long guiding wings to the carriage results from the method of driving the carriage from the extreme of one side, and also from the leverage exerted upon the tool-point in certain positions. It is an argument urged against the V-shear system that the long span of the saddle to clear the inner rail makes a greater thickness of metal necessary at that part for stiffness, and therefore reduces the swing of the lathe. The shortest radius from the center to the shear limits the face-plate work which the lathe will take in. In long work the limit is fixed by the shortest distance from the axis to the saddle, and the thinner this is the greater the swing of the lathe. This difficulty is met by thickening the metal of the saddle downward between the shears. Nearer the abutments the depth may be reduced. The majority of the carriages are what are called half-gibbed. The gibs take hold below the outer back and the inner front of the shears. Flat-shear and many V-shear carriages are gibbed at the outside, back and front. There are comparatively few which are gibbed on all four surfaces.

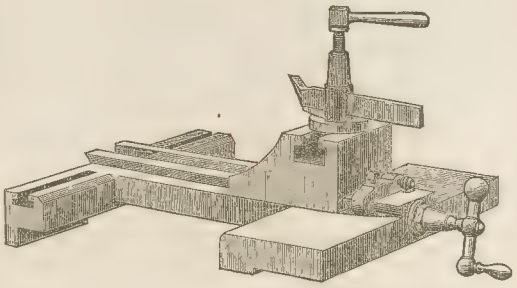


Fig. 93.

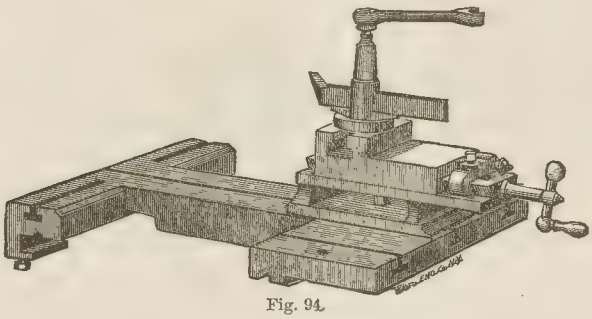


Fig. 94.

Fig. 93 shows the ordinary plain gibbed rest for small and average lathes. The apron which holds the driving gear, to move the rest automatically, is secured to the flat surface at the under side of the front. The cut shows the ordinary tool-post, consisting of a block with a T- socket in its top. The post is slotted out so that the shank

of the tool may pass through it, and a set-screw in the axis of the post screws down upon the tool. The abutment is the round head which fits into the T-slot and binds tool and post to the block. For the adjustment of the point of the tool, that it may come opposite the horizontal diameter of the work, is the object of the washer below the tool. This is dished out into a segment of a hollow sphere, and a steel segment of a zone of the same sphere fits into the hollow. The tool rests upon the flat surface of the wedge, whose spherical lower side permits the tool to have a full bearing at any vertical angle within the necessary limits. The same object may be attained by a spiral washer under the tool.

It is the block below the tool-post which receives the cross motion at right angles to the axis of the lathe. Upon the saddle are planed flat, dovetail shears, truly at right angles to those of the carriage below. The post and block can be moved on its shears by the cross-feed screw which holds against the carriage between a shoulder and the ball-handle spacer-washers. The tool-block is made with long bearing surfaces, and any wear in its fit is taken up by screws which bear upon an adjustable gib. The T-slots on the rear wings are planed out to receive a back-rest or any other convenient attachment. On larger lathes, what is known as the "Philadelphia rest" is often used (Fig. 94). An open casting slides in a T-slot across the carriage, to which it can be bolted. The shears for the tool-block are on the top of this adjustable foot. The advantage of this form is that it can be bolted to any part of the rest by the T-slots wherever the exigencies of the work may demand, or the whole tool-holder can be removed, so that the flat carriage only may be left. The cross motion, however, cannot be automatic.

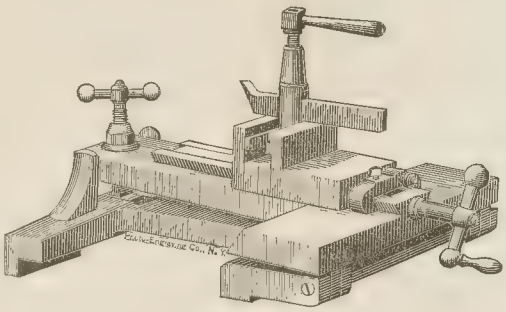


Fig. 95.

For many classes of light job-work the easy, rapid, and secure adjustment of the point of the tool is of considerable moment. To effect this is the object of the gibbed rest shown in Fig. 95. The saddle is made double, the top half revolving around a horizontal hinge at the front. The lifting-saddle is prevented from twisting strain

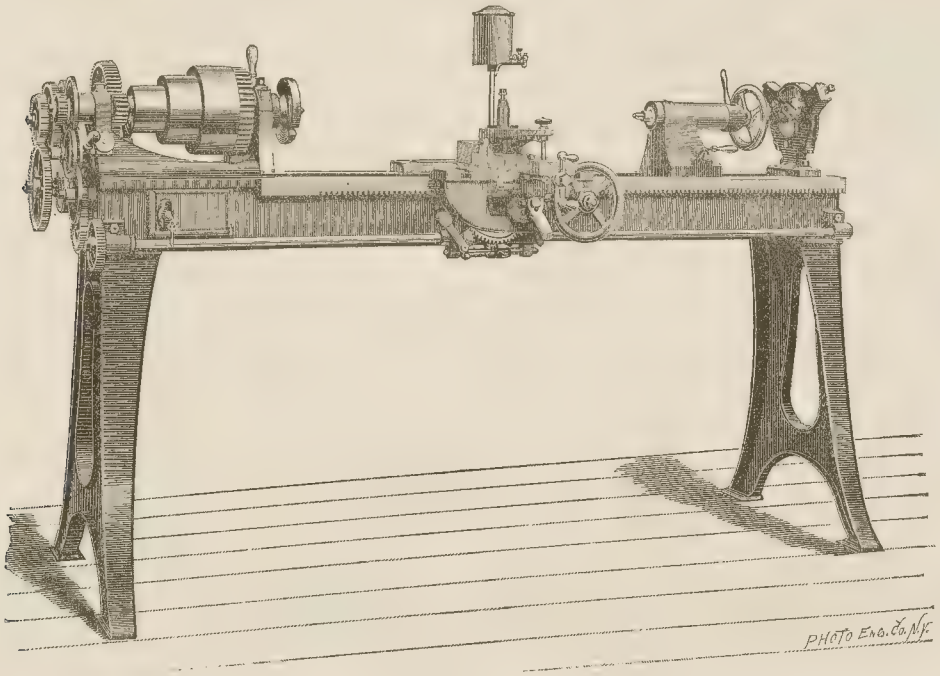


Fig. 96.

by the faced brackets at the back, and the degree of elevation of the rear end is controllable by a screw, which passes down into the lower saddle. The motion of the screw in the upper and lower saddle is circular around horizontal axes (Fig. 96). This is provided for, and lost motion is taken up by several devices. The most usual

is to make the lower end of the screw spherical, which fits between brass washers, curved to fit the ball. These washers are confined by a screw-sleeve in the top of the lower saddle, by which any play can be taken up. In the upper saddle the nut for the screw is also made externally spherical and confined by similar sleeves. Others pin the end of the lifting-screw into a slide on the lower saddle, so as to avoid the ball-and-socket fit. Wear is taken up in the nut by splitting it across the axis, and controlling the approach of the two parts either by the sleeve-nuts or by conical-pointed set-screws. In rests of this type the tool-block slot is so made as to give a stiff hold for the tool at a distance from the set-screw. Not infrequently the top of the block is serrated to increase the friction.

Other methods of raising and lowering the tool-point are shown by Figs. 88 and 91. In Fig. 88 the gibbed block slides over a shear on the surface of a horizontal cylinder. A rack on the end of a screw meshes into a sector on this cylinder, and the point of the tool rises in an arc. Another device has the cylindrical surface replaced by a spherical surface, the head of the slotted bolt coinciding with the center of the sphere. This works very well as long as there are no defects in the spherical contact. Still another uses inclined planes on the two halves of the post, controllable by a separate screw. The disadvantage of these methods is that horizontal adjustment of the block must be made after every vertical change. A joint where lost motion may occur is also introduced between the tool and the carriage. Another plan, which has the advantage of stiffness, makes the post with a screw-thread on its lower part. By raising and lowering this large pillar-screw the point rises and falls. One similar design raises the tool by a capstan-nut on the outside of the post, while internal to the post is another which acts to clamp the whole from moving. In still another the pillar of the post is lifted by an elbow-joint, clamped by the screw which controls the joint.

For small lathes an especial practice prevails in New England. The slide-rest carriage, moving on V-shears, is kept to its bearing on the track by a weight, and no gibs are employed. This system gives great steadiness of motion for light cuts, since all lost motion of adjustment and for free travel is absorbed in the weight. The hinged saddle is used, lifted by the end screw by contact joint only, and no "take-up" devices are required (Fig. 97). The cross-feed can be only limited in length on this system. When wide surfaces are to be faced, the post-block must be reset in the slot. No tools of this design are approved at the South or West, but in New England they are preferred by many of the best workmen and builders. As the swing of the lathe increases the height of the tool-post must increase also. To increase the capacity of the tool-holder, the compound rest is approved. The lower block, which may travel across the bed at right angles to the axis of the lathe, carries a horizontal flat disk with a circular T- slot in it. Upon this disk may be bolted at any angle a secondary tool-post, which has a screw cross-feed motion upon its own shears (Fig. 98). So that, beside the two motions at right angles to each other, which are common to the smaller devices and are here retained, the tool may have an angular feed in any direction for turning tapers and conical shapes. On lathes of the largest size, where the pillar on which the tool-holder stands is quite high and the cuts will probably be heavy, the form shown in Figs. 99 or 100 is used. The tool is held by two clampings-crews, and while the large post has the two original motions, the holder on the top has also two motions at right angles for convenient use by hand. In newer practice, even these feeds can be driven by power for smaller work.

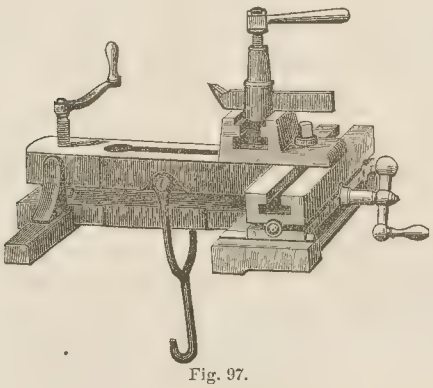


Fig. 97.

To actuate these carriages automatically by the power of the tool itself two general systems are in use. One moves the carriage by a screw, whose nut is held in the apron of the carriage, and the other by a driven pinion in the apron, which meshes into a rack on the under side of the shear. Both systems may be combined in one lathe for different uses. The screw-feed will be used for the reproduction of screws; the feed by the pinion, usually known as the "friction-feed", will be used for the general turning in the lathe. The driving-screw is continuous for the whole length of the bed. It is often called the "lead-screw" or the "feed-screw". In very long lathes it has to be supported to prevent sagging between supports. This is accomplished by flat hooks, which catch hold of the shears and pass under the screw. They are perfectly movable and can be put where most needed. Usually they bear on the tops of the thread of the screw. The thread may be cut away for a length less than that of the nut in the apron if it is desired to give the supporting hooks a complete straight bearing. The lead-screw may be put in front of the bed, at the back of the bed or between the shears.

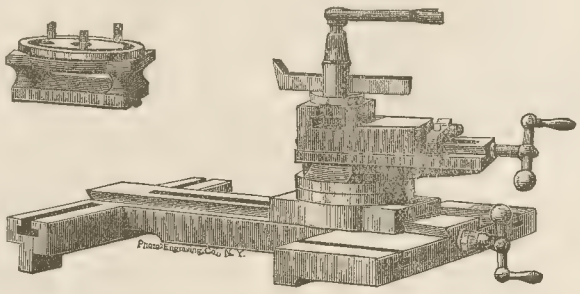


Fig. 98.

There is but one designer using this latter system. In this make, the screw is supported in a trough in the shear casting, and is protected from chips by the projection of the shear. A half-nut or chasing-nut is used on the carriage. The preponderance of practice has the screw in front of the bed. The friction-feed apparatus is always in front.

The screw is driven by a train of gear-wheels from the spindle of the lathe. These wheels come in sets, so

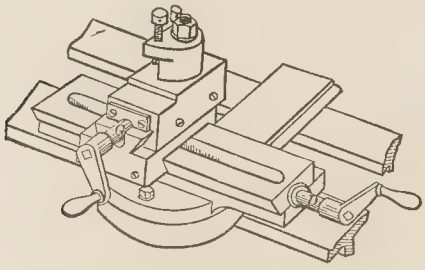


Fig. 99.

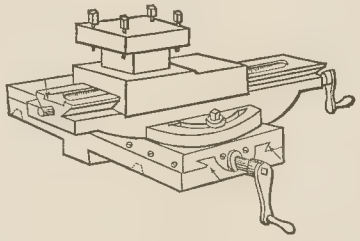


Fig. 100.

that almost any esired combination may be interposed between the spindle and the screw, to vary their relative velocities. If the spindle and the screw turn at the same rate, the tool-point will cut a duplicate of the lead-screw on the work, since each will have gone round the same number of times while the tool moved over one inch. To cut any other thread the revolutions or the number of teeth on the wheels of the first and last of the train must be as the thread to be cut is to the thread of the feed-screw. It is therefore convenient that the pitch of the feed-screw be a convenient divisor of the usual threads. Very often it has four threads to the inch. One designer uses two threads to the inch, for convenience of calculation and to make it more easy to strike into the thread under the cut. To connect these fixed studs at the two ends of the train the studs upon which the intermediate idle wheels are placed are borne upon a slotted swinging casting, which revolves around the screw or its journal as a center. The studs for the wheels take into these slots, and the casting is clamped by a set-screw to the head of the lathe (Fig. 101).

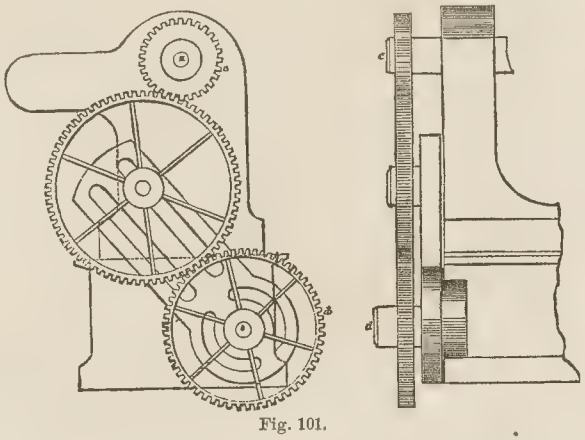


Fig. 101.

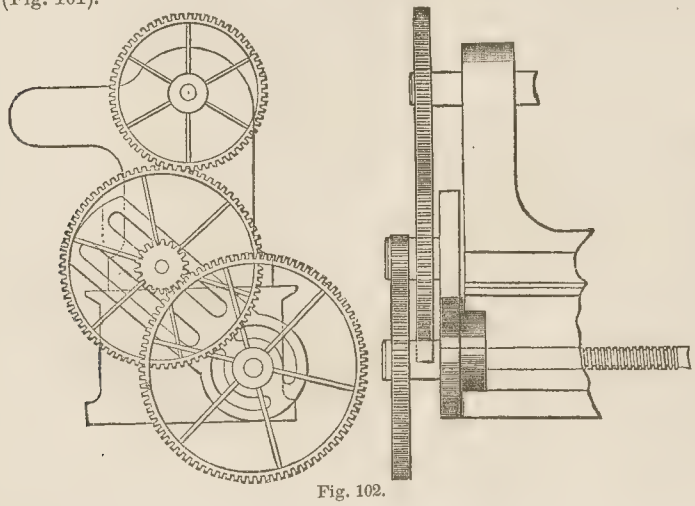


Fig. 102.

Many lathes of large swing having a large feed-screw with small number of threads to the inch will be double-geared or compound-geared. By this is meant that upon one idle shaft are two gears of different diameters turning together. A larger range of speed between the spindle and screw is obtainable with few gears. To avoid confusing the operator with different motions for reversing it is best always to have the same number of spindles in the train. Also, the use of a large gear on the screw may be avoided, necessitating a cut in the floor, and heavy gears are dispensed with. There may be also the gain due to the greater smoothness of working when the driver and follower-gears are more nearly of the same size than would be possible with the single gear. The arrangement is shown by Fig. 102. While it used to be 12 per inch, it is now 6, and some prefer 4 per inch. The tendency is toward smaller diametral pitch in the change-wheels.

For reversing the motion of the screw in general practice one method is preferred. It depends on the principle that in any train of external gears the even numbers in the series will be turning in one direction and the odd numbers turn in the other. By a simple motion of a lever the train of gears driving the screw may be made to contain an odd or an even number of wheels. In Fig. 103 a V-shaped lever turns at its apex on the stud of one wheel as a center. On one arm of the V is one wheel and on the other are two. If the V is rotated so as to bring the driving-pinion D into gear with one arm, the follower at the apex will turn one way; if with the other arm, the follower will turn the other way. There is, of course, a neutral position, in which the driving-pinion will drive neither. The lever which moves the V projects conveniently for the hand of the operator, and is prevented from disengaging itself either by a latch-pin into holes, or by a clamp-screw, or by a little cam. The clamp-screw requires the use of both hands.

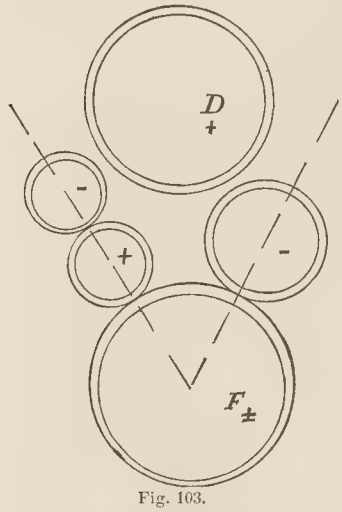


Fig. 103.

Another type of reversing mechanism uses the principle of the two loose bevel-gears driven by the third between them. The combination is put under the cone-pulleys, and a clutch is engaged by a rod from the apron with one or the other of the loose gears. The advantage of engaging and reversing at the head also rather than at the carriage only is that, when speeding the lathe for polishing, the gears need not be clattering and wearing each other out. For engaging and disengaging at the carriage, the universal device is a split nut. This is divided along a plane through the axis into two parts, which approach to clasp the screw or recede to release it at the will of the operator. This clasp-nut has the halves moving in guides so as truly to come together and make a nut, the motion to open and close being given to both parts. Usually this motion is given by a disk in which are two spiral slots. In these slots fit two pins, of which one belongs to each half of the nut. The slots are so laid out that when a partial rotation is given to the disk the pins come equally toward its center or recede from it, carrying the sliding halves of the nut. Another device draws the halves together by fitting them to a bolt with a right thread on one half and a left thread on the other.

This clasp-nut device is practically universal in lathes driven from the screw in the apron. A New England design, with the screw at the back, uses a solid nut, which bolts through a bracket to the saddle by easy working tap-screws, when required. This system of solid nut renders obligatory the use of reversing counter-shafts—a system expedient in all cases for the economy of time and exactness of screw profile. Left threads are cut in this single-connection system by putting an extra idle-wheel in the gear-train.

The use of the screw and nut for ordinary turning-feeds has two objections. The principal one is the wear of the screw, which will be greatest near the head-stock where the greatest amount of work will be done. Therefore a long screw cut on such a lathe will not be uniform or regular. The nut will also wear and permit lost motion. A second minor objection is that the ordinary feeds are so much slower than a screw-cutting feed that considerable rearrangement of the train is necessary to get the proper speeds when the work varies. To avoid these difficulties, nearly all the smaller and medium lathes of to-day are provided with a second feed system, known usually as the "friction-feed". Motion is imparted to a train of gears in the apron of the rest, by which a small pinion is made to turn in gear with a stationary rack upon the shear. This train of gears is engaged and disengaged by a friction-clutch in the apron.

Figs. 104 and 105 show a plan and elevation of a very usual form of the gears in the apron. The rod *f* is driven by a narrow belt from a cone-pulley on the first spindle of the change-wheel train. There are usually three changes

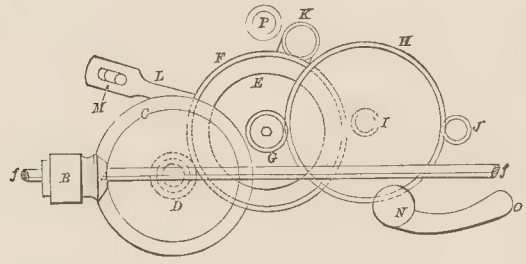


Fig. 104.

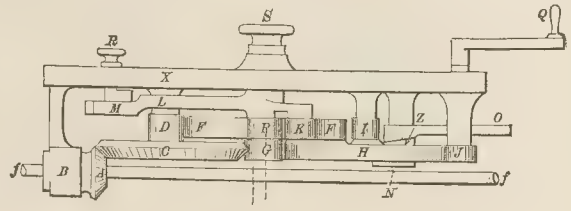


Fig. 105.

on the cone, and the reversing is done either by the lever with the one and two gears, or by crossing the little belt, or it may be done in the apron. This rod is splined, and carries a bevel-wheel, A, mounted on a bracket, B, from the apron. The rotation of *f* will therefore turn A wherever the latter may be upon the rod. When A revolves,

it turns the wheel F, which is the female part of a friction-cone. The rest of the train, up to the rack, is connected with the male part of the cone (Fig. 105) through the pinion G. The cone is engaged by the screw Y, controlled from outside by the hand-nut S. The wheel H catches in the rack under the shear, and on the axis of the pinion J is put the ball-crank or hand-wheel for traversing the carriage by hand. It will be seen that if a second bevel-pinion be put opposite to A, so that either may be at will engaged with C, a very simple reversing and disengaging gear is designed, which is worked from the carriage entirely, without stepping to the head. In many designs the bevel-gear A is replaced by a worm. This permits the reduction of speed to be made with few wheels in the train. For reversing in the apron, one designer has one right and one left worm on the rod, either of which can be brought under the worm-wheel by a lever in front.

The worm-system is objected to by many builders on account of the danger to it if allowed to get dry by neglect. The wear of the surfaces becomes very rapid. The wheel is made of cast iron, the worm of wrought iron, steel, or cast iron. In some cases it turns in an oil-pan to keep it lubricated. Very often, instead of driving the wheels in the apron from a separate splined rod, the feed-screw is splined to carry the worm on the bevel-gear. This is objected to by some on the ground of the wear on the top of the thread and at the points of the threads where they are cut by the spline. One designer gears the rod to the screw and drives both at once (Fig. 89). The end play of the screw is prevented by a steel step-screw or by a washer of some material like rawhide. When a lathe has both feeds in the apron there have been devices to prevent the operator from throwing in both at once. For reasons of simplicity of mechanism this attachment is not often applied. The gears are usually carried on studs bolted into the apron. To avoid the strains on the overhanging bearings one designer makes the apron with two walls (Fig. 81). Another plan has all the gearing on the outside in front (Fig. 89); this is a gain in cleanliness, but there is more danger of accident to a careless operator. The rod-feed of the lathe shown in Fig. 80 is driven by a friction device by means of which the speed of feed may be varied. A smooth disk of cast iron is the driver, which is clasped by two disks of brass upon its sides. These disks of brass are kept against the iron by a stiff steel spiral spring. A second disk of cast iron upon the splined rod is driven by the contact of the brass plates on the side of their axis opposite to that of the driver. The axis of the connecting plates is movable along the line of centers of the driver and follower disks, so that any ratio of radii within the limits of the design can be secured. In this lathe also the screw is not clamped between the two halves of a nut, but a half-nut presses against the screw laterally, and flexure is prevented by the shape of the shear casting. In the Sellers small lathe the rod-feed is often driven by their frequent device of a concealed worm or spiral pinion. In the Miles lathe the feed is driven by an original device to avoid the loss of time in changing the gear-train (Fig. 106). The live-spindle is

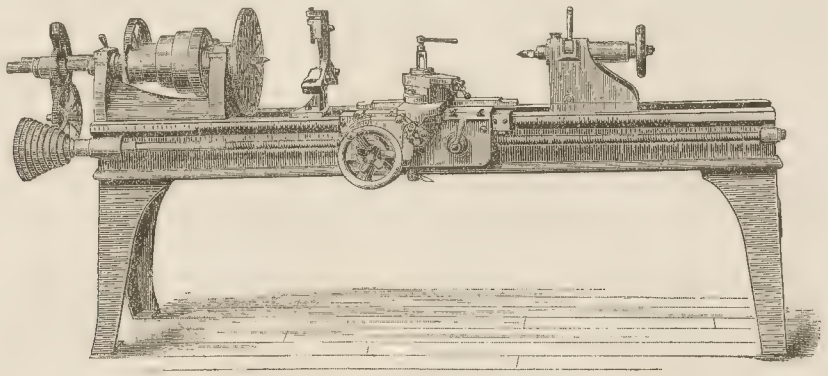


Fig. 106.

prolonged for some distance at the head of the lathe, and is splined to carry a spur-wheel and pinion. At the rear of this spindle is a round horizontal pillar, upon which slides an arm, carrying an idle wheel on a horizontal stud which can connect either spur-wheel or pinion to a nest of gear-wheels of different diameters fast on the screw. The pillar is graduated so that the edge of the arm may be rightly clamped to cause the proper thread to be cut. Changes of feed speed by this arrangement are very simple and rapid and the gear is durable. The racks under the shears are usually in segments, screwed in place. They are of wrought iron, steel, or cast iron. Steel is preferred by some because of the weakness of the teeth of fine racks under strain of the feed.

The screw for the cross-feed of the tool-post is most frequently engaged by a second friction-clutch operated like the other by a screw (Fig. 78). This takes hold of the gear before the other, so that both may be used at once or only the one which is required.

The arrangement shown in Fig. 104 is a type of another system where the connection is made by moving an idle pinion into the train. The pinion K is on a stud upon an arm which turns around the axis of the driving cone-

wheel F. A slight motion of the arm around its center will put the idle pinion into gear with the pinion on the cross-screw P. This can only be reversed by reversing the motion of the rod. For large wheel-turning lathes and the like, the cross-feed has often been driven by a click and ratchet motion by a weighted lever (Fig. 107). A

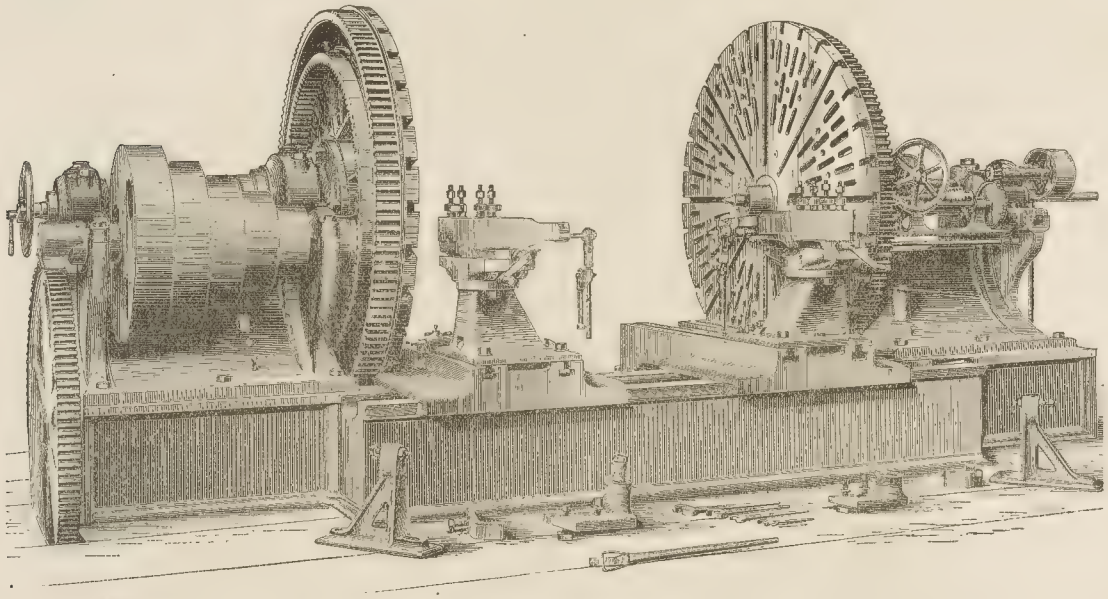


Fig. 107.

rope passes from an adjustable crank at the head-stock to a pivoted lever overhead, and from thence a second rope comes down to the ratchet lever on the screw. The intermittence of the motion is compensated for in the spring of the tool. A longitudinal ratchet-feed is not now used to any extent (Fig. 86). The saddle may be clamped against longitudinal motion when cross-feeding by a movable gib, or by any convenient device.

To avoid the inconvenience that the friction-cones in the apron will sometimes set themselves, a designer in Philadelphia makes the clutch cylindrical, of a split steel ring, kept open by a little cam. When the cam is turned the ring closes and engages the gear. There are several devices in use to prevent the unintentional seizure of the conical forms.

Every lathe has certain accessory appliances as part of its furniture. One of these is called the "steady-rest". It is intended to support long cylindrical work which might sag by its own weight between centers. It consists of a frame to support three radial sliding jaws which can be moved toward the axis of the tool by screws. The rest

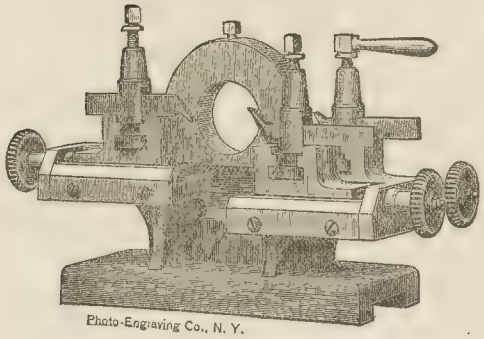


Fig. 108.

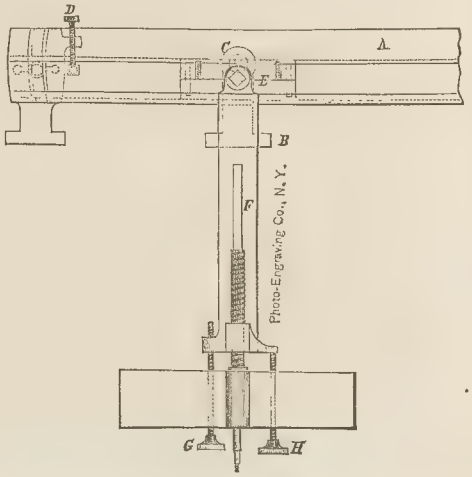


Fig. 109.

stands on the shears and is clamped by a cross-piece below. The cylindrical frame which holds the jaws is split at the horizontal diameter for convenience of inserting and removing work, two of the jaws lying at angles of 30° below the horizontal line. When the work is not cylindrical, a shell "doctor" with radial set-screws in pairs can be secured to the work so as to turn centrally upon the jaws of the rest. To resist the horizontal spring of light work away from the tool-point, a "back-rest" is used. A curved upright bolts in T-slots in the carriage, and adjustable jaws oppose the pressure of the tool. These difficulties are overcome in lathes for turning shafting by making the rest on the duplex system (Fig. 108). There are two tools opposite each other, one turned up and one turned down. A third tool may produce the finishing cut, and the shaft may be sized perfectly by a hollow reamer.

A type of the attachments for turning tapers on a lathe is shown in plan in Fig. 109, and in place on the lathe in Fig. 110. At the back of the bed are three brackets which carry a grooved bar. This bar can be adjusted

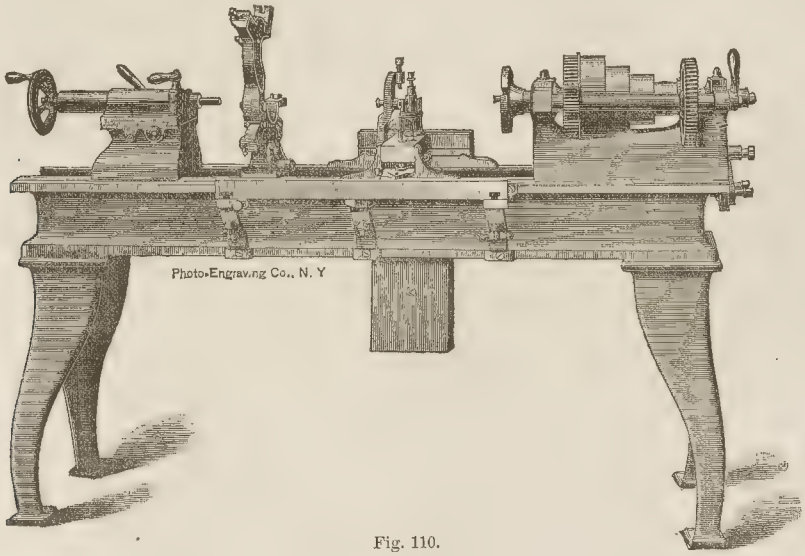


Fig. 110.

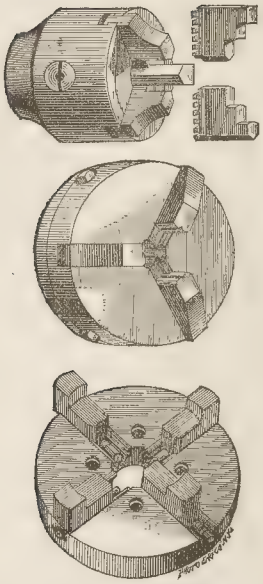


Fig. 111 *a*.

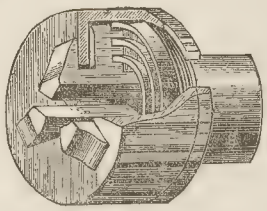


Fig. 111 *b*.

parallel to the axis of the tool or at any angle with its horizontal projection. In this groove slides a block, E, which is pinned to the nut-bar F, which slides in a groove in the lower part of the tool-carriage. G and H are stop-screws to be used in outside and inside work respectively. When the bar A is swung around its center pin, C, and clamped into the required position as determined by the tangent-screw D, a gradual transverse motion is imparted to the upper part of the tool-carriage in and out from the centers. This type of attachment is unaffected by the length of the piece, requires no preliminary cuts for trial of the taper, works as well for inside work as for outside, and avoids setting the centers out of line. A similar type which avoids any lost motion of the slide in the groove holds the guiding surfaces in contact by a weight over a pulley.

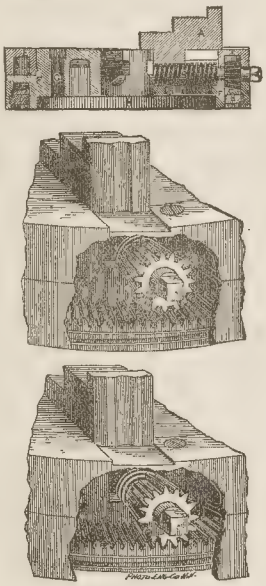


Fig. 112.

A universal or self-centering chuck is a usual accessory. These are made for small and medium lathes upon two principles. The jaws are usually three or four in number, sliding in radial grooves. The scroll-chucks have a plate with a continuous flat spiral groove cut in it. The jaws have projecting lips, which enter the groove, and when the scroll-plate is turned the jaws all move equally toward the center (Fig. 111 *b*).

The second type has the jaws mounted and moved inward by screws. These screws have each a small pinion near the outer end meshing into a large gear concentric with the chuck. When one of the screws is turned the others must all turn equally and the jaws will move to the center. Fig. 111 *b* shows a type of scroll-chuck. Fig. 112 is a screw-chuck of the second type. The screw type enables the lost motion due to wear to be taken up. Each screw can be separately tightened by the wrench in this form, since the two gears may be disengaged. The special chucks, the drill-chucks, and the eccentric-chuck, the mandrels, and the dogs and drivers, are articles of especial purchase or manufacture.

§ 17.

SPECIAL FORMS OF LATHE.

Special constructions of lathes are adapted for special uses. Where a large chucking capacity may be called for, but only average swing over the rest of the bed, a gap-lathe (Fig. 113) may be used. This gap may be permanent, or the shears may be in two tiers, the upper or working bed sliding over the gap when it is not needed. Where work is always to be of large diameter and flat, of such a shape as to be worked best on the face-plate, the bed may be made short and the tail-stock may be omitted. This form of lathe will be called a chucking-lathe (Fig. 114). For very large fly-wheels and work of that class a chucking-lathe only is required, and very often the face-plate and tool-carriage rest upon separate foundations, and are really separate machines.

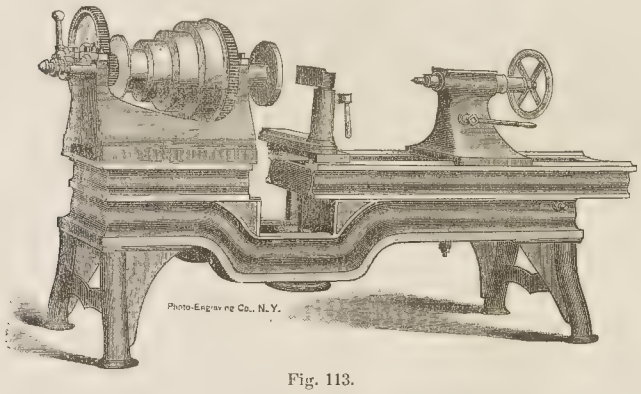


Fig. 113.

A lathe especially adapted for locomotive driving-wheels is shown by Fig. 115. There are two large face-plates driven from pinions on splined shafts. This avoids the twisting strain on the axle when the resistance comes at the end of a long lever. The frames of the heads are of the box pattern, giving great stiffness. There are two tool-

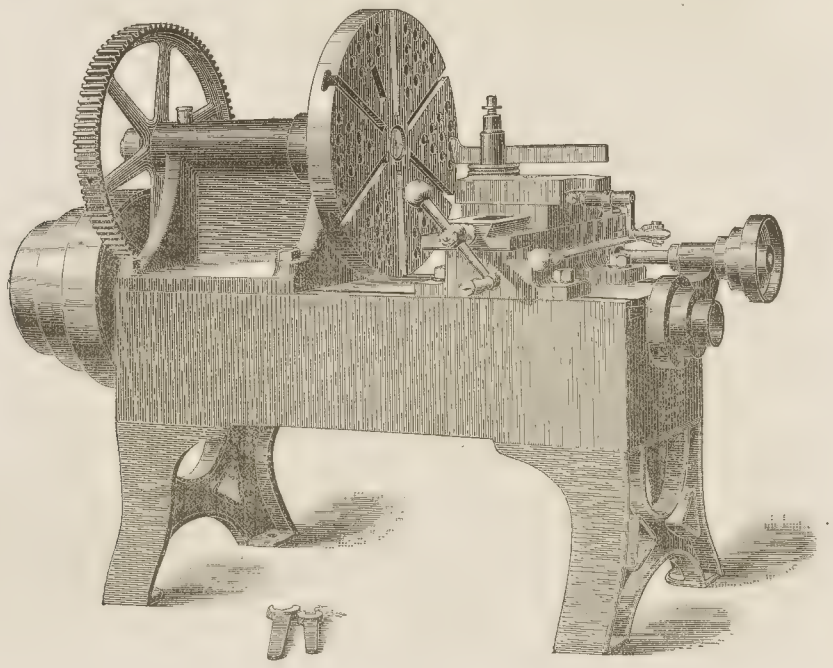


Fig. 114.

posts, and a facing-rest may be secured to the face-plates. Upon the tool-posts may be secured a quartering device for boring the holes for crank-pins at exactly 90° with each other. In other forms of this same tool the quartering attachments are secured to the frames, so that the spindle passes through the face-plates. The tool-posts clamp in place and are fed from overhead.

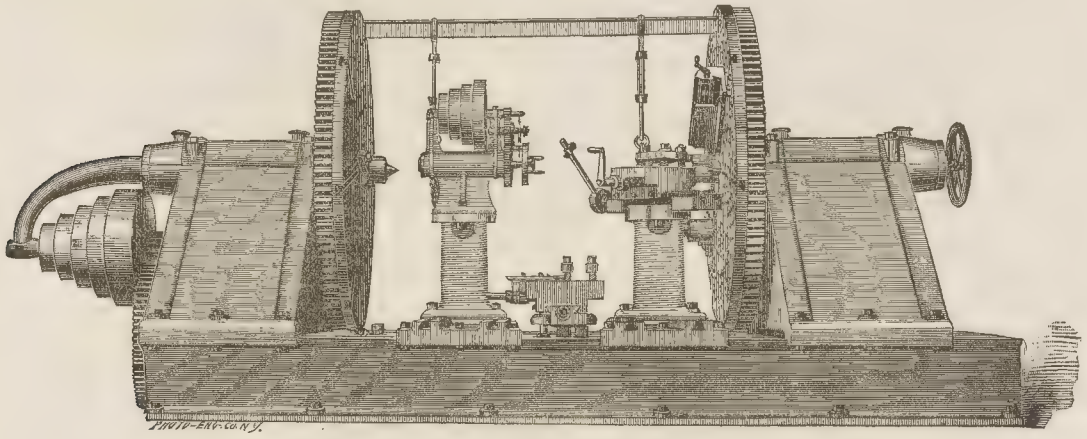


Fig. 115.

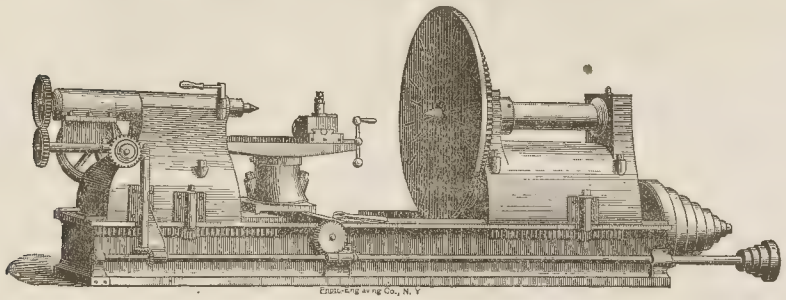


Fig. 116.

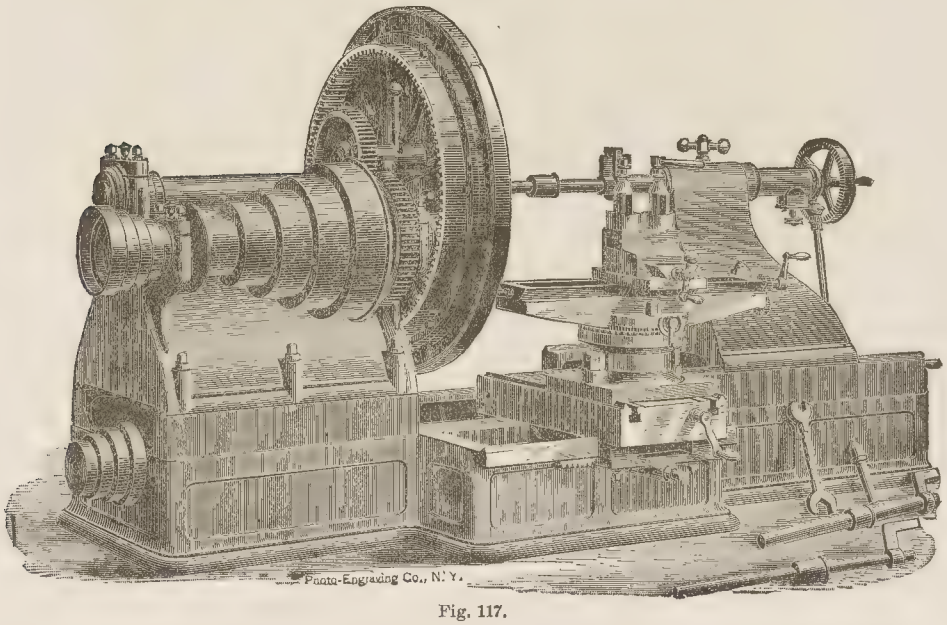


Fig. 117.

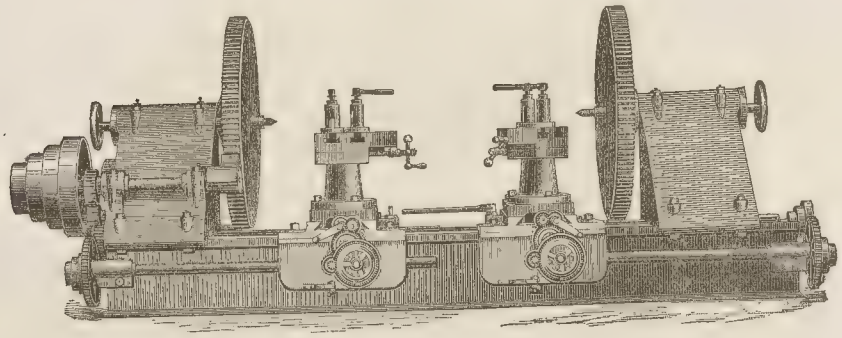


Fig. 118.

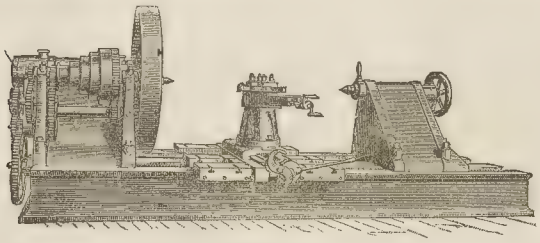


Fig. 119.

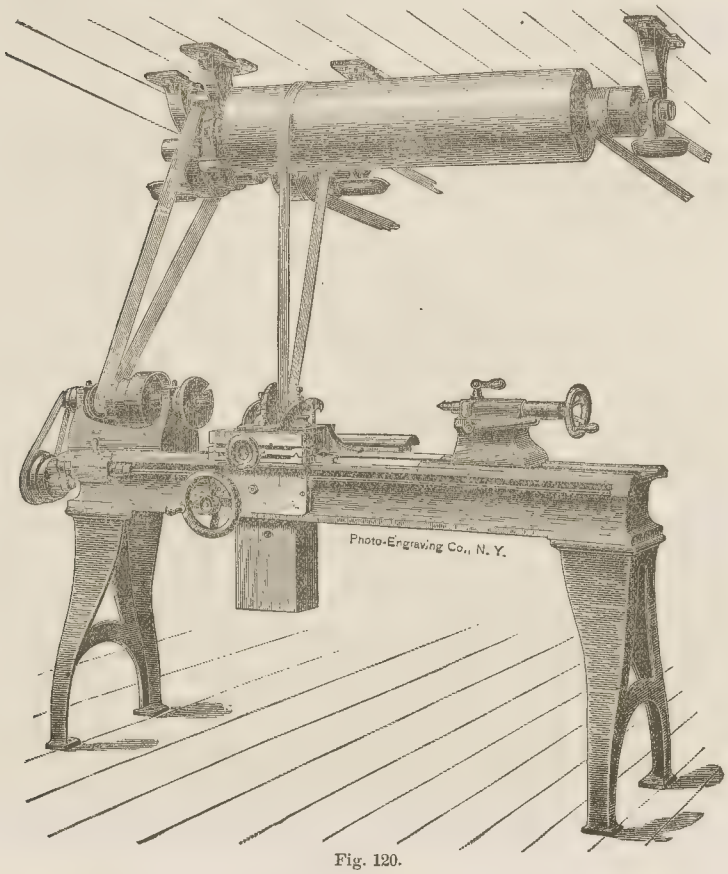


Fig. 120.

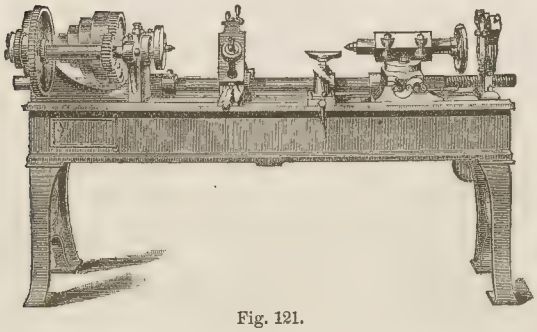


Fig. 121.

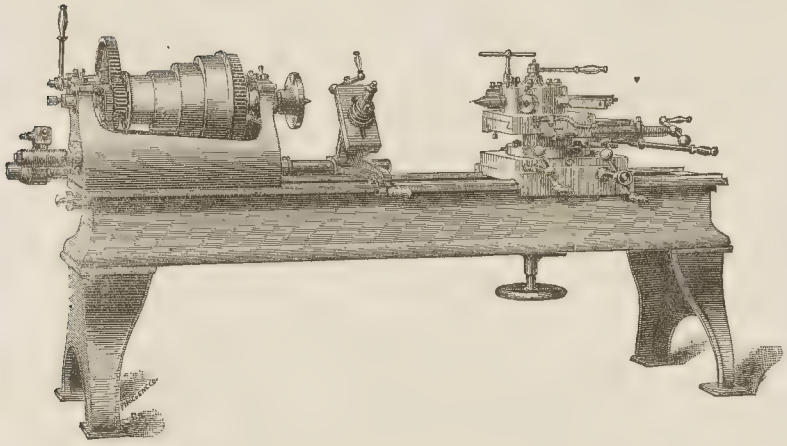


Fig. 122.

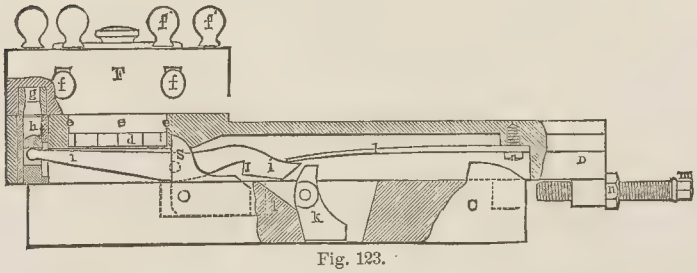


Fig. 123.

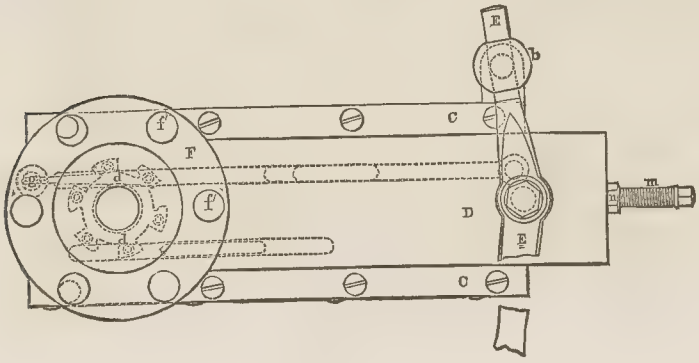


Fig. 124.

The lathe of Fig. 116 has one or two stationary tool-posts. The head- and tail-stock are both made movable by rack and pinion along the bed. The face-plate is driven from a splined shaft below the shears. The tail-spindle has power-feed for boring from the feed-shaft at the back. The feed for the tool is carried up vertically by bevel-gear through the center of the post, and at the top is carried to the feed-screws by double bevel-gear, giving motion forward or backward at will. The driving-axis, being central to the post, permits feed at any angle. The movable heads with stationary post gives great steadiness and stiffness. A slightly different tool with similar facilities is shown by Fig. 117. Figs. 118 and 119 show types of lathes of very large swing.

For the exact sizing of hardened steel spindles and the like the cutting has to be done by an emery-wheel. Fig. 120 shows the arrangement for such lathes, the grinding-spindle being driven by a separate counter-shaft, with a long drum. The shear-tracks are protected from the emery-dust by guards. The slide-rest has an automatic longitudinal traverse in both directions, the reversing being done by double bevel-gears and a clutch connected with the feed-rod. It can grind tapers as well as cylindrical surfaces.

For reduplicating small chucked work in the soft metals what is called a chasing-lathe (Fig. 121) is in very general use. It is not intended for turning work between centers, but it can be so used if desired. The head-stock receives motion in the usual way by cone-pulleys and back-gear. The tail-stock has also two motions, so that a tool can be inserted in the squared spindle, and by working the cross-feed to a stop any standard diameter can be reproduced without the loss of time for calibrating. It can also be set to cut tapers. The slide-rest is clamped upon a guided bar at the back, and is brought to its work by a handle, which is pressed down upon the front shear. The tool-post is fed upon an inclined shear by a screw. An arm on the guided bar carries a half-nut, which is brought into gear with a chasing-hob, driven from the live-spindle by the movement of the handle which brings the tool to its cut. The spindle carrying the hobs can carry two of different pitches, and a single-pointed tool can cut single, double, or quadruple threads. The slide-rest is counter-weighted so as to be brought up against a collar on either side at will when released from the chasing-hob. This collar can also serve as stop to prevent any given operation from being carried further than a certain length on the work. A hand-rest enables small finishing and chamfering cuts to be made by hand. A tool of this kind is adapted for miscellaneous work in brass, such as globe-valve and lubricator work, which it does very rapidly, exactly, and at one chucking.

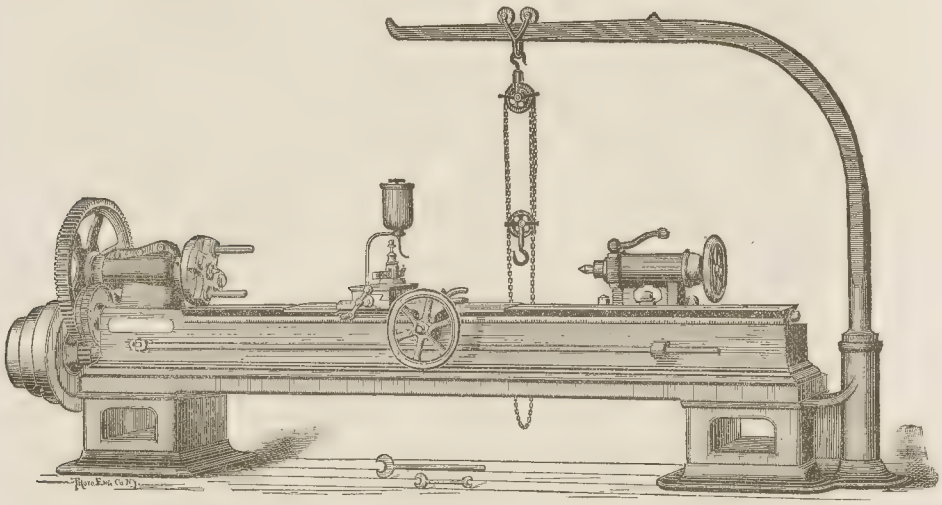


Fig. 125.

A similar tool, differing only in the construction of the tail-stock, is shown by Fig. 122. This tool is fitted with what is called a turret-head. A vertical cylinder, like a monitor turret, has six radial openings in the vertical surface, each of which carries a tool adapted for a different operation on the work. After the lower block has been clamped, the turret may receive its various motions by levers or by screws acting against adjustable stops. The interior construction of the turret-head and slide of one of the best forms is shown by Figs. 123 and 124. The lever E moves the slide D to the right and to the left. As the slide D carries the turret F to the right, the lug S strikes projections *d* on the bottom of the turret and gives it a partial rotation around its axis. That the proper amount of rotation may be given and the turret locked in the right place is the object of the pin *h*. This pin is thrown up into spaced holes in the bottom of the turret by the lever *i*, when it is released from the catch *k*. When D is moved to the right the pin is withdrawn from the hole *g*, and the end of *i* passes over the catch *k*. The movement of D in the other direction causes *i* to be released from *k*, and when the hole comes opposite the pin the

spring *r* forces the former upward and locks the turret. The pin and the bushing *s* of the holes are made conical, so as to come to an exact fit, and are hardened to prevent wear. In the lathe illustrated the disagreement of the centers, which is such an annoyance in turret-lathe work, is avoided by an especial device. The head-stock swivels, and at its juncture with the bed is a tongue which permits the head to be raised by the elevating-screw under the head while preventing lateral displacement. If the centers do not agree, standard tools in the turret will turn work out of size.

For turning locomotive- and car-axles an especial design of lathe is preferred. These are of two kinds, the single head and the double head. The single-head machine acts on one end at a time only. Such an one would

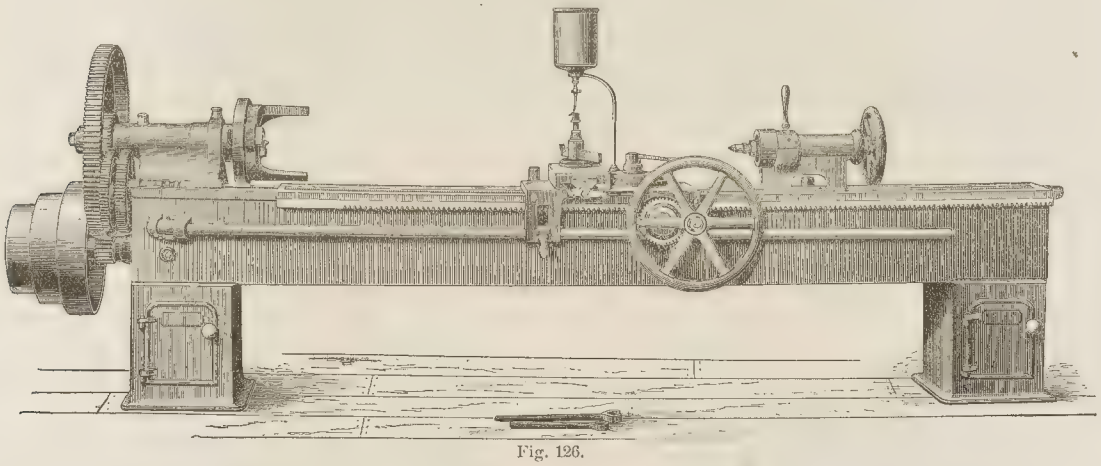


Fig. 126.

be illustrated by Fig. 125. The shears are flat, since the strain can come inside of them, the tail-head moving on a lower plane than the carriage. The head-stock is made adjustable for wear by the split in the casing, which is

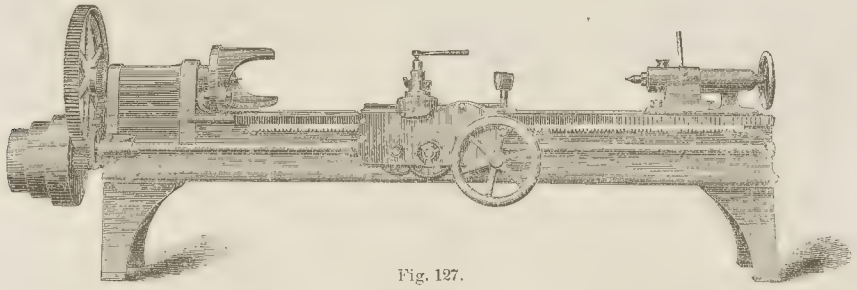


Fig. 127.

kept together by bolts. To equalize the turning strain on the axle when under the cut it is driven by two pins on the face-plate. There are two speeds of the tool for roughing and finishing which are caused by the two sets of pulleys on the counter-shaft. The two sets of feeds are produced at the head by the rod in front of the bed. The crane with differential pulley-gear enables the work to be handled easily.

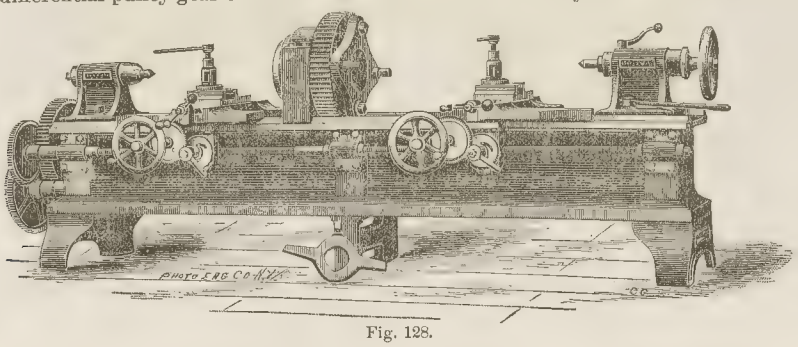


Fig. 128.

Differing only in some of the details are the car-axle lathes shown in Figs. 126 and 127. The lathe of Fig. 128 is one of the double-headed type. The axle is driven by a driver from the middle, and there is a tool-post for each

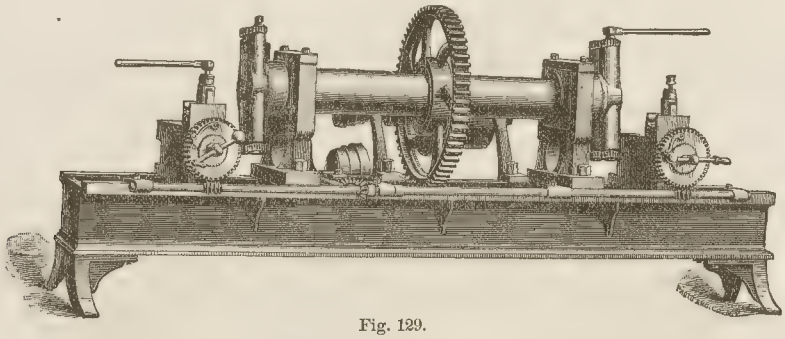


Fig. 129.

end, so that the two ends may be worked at once. The driving-pin plate is not rigidly bolted to the gear-wheel head, but has a certain diametral adjustment in slots. This enables the driver to be acted on equally by both pins,

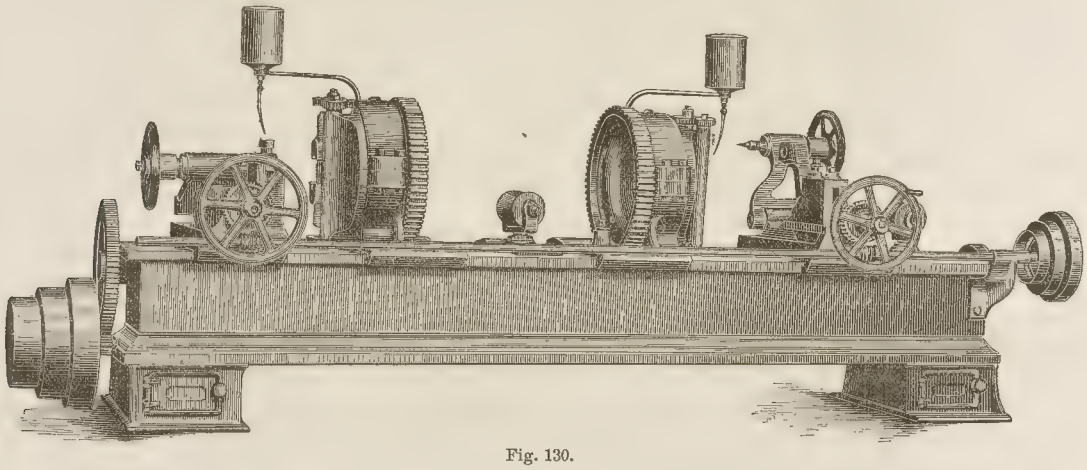


Fig. 130.

and avoids the tendency to spring sidewise which is not infrequently manifested when the axle is driven from a jaw-chuck. When this happens the work is out of round when released.

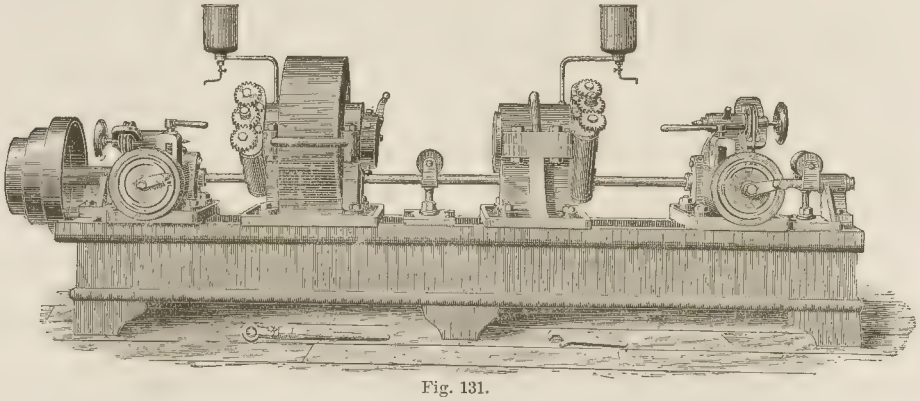


Fig. 131.

Another type of double-headed lathe is shown by Fig. 129. The axle is driven by jaws close to the cut, and the slide-rests have lateral and longitudinal power feed. By this system it is unnecessary to center the axles after being cut.

For cutting off and centering axles as they come from the hammer the tool shown by Fig. 130 is in use. The axle is driven at each end from the splined shaft within the bed, and cutting-off tools are fed against them at the proper length. When the crop-ends are removed the centering-heads may be fed into the end to drill and countersink for the center of the lathe which is to follow. The centering-heads can be swung out of the way when not in use. Fig. 131 illustrates another form of the same tool. A machine for centering only, after the crop ends have been removed, is shown by Fig. 132. The jaws are moved by right-and-left screw, and the center drill is fed rapidly by a rack and hand-wheel. An axle can be centered in three minutes by this machine.

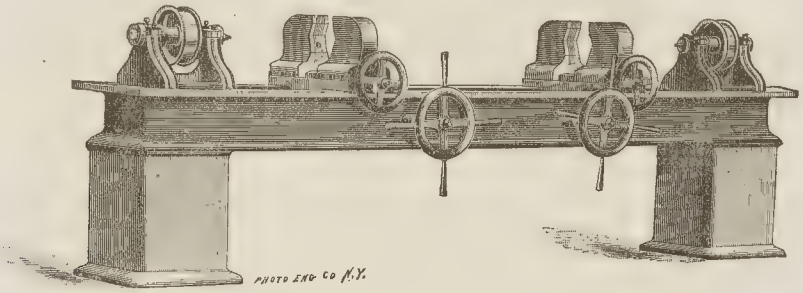


Fig. 132.

The lathe shown in Fig. 133 differs from the preceding in using a bed of a cylindrical section, with flats raised for the poppet-head and slide-rest. The feed is by a worm of four threads meshing into a rack on the front of the bed. The axle is driven by what is known as Clements' driver on the face-plate. The gearing is strong enough to rough out the journal in one cut of a depth of $\frac{3}{4}$ or $\frac{7}{8}$ of an inch. For centering the rough axle and sizing the wheel-fit the machine shown in Fig. 134 is used. The axle is driven from a powerful chuck lined with brass. This

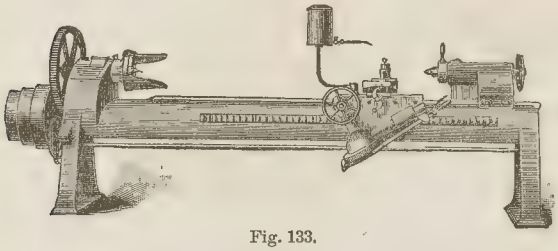


Fig. 133.

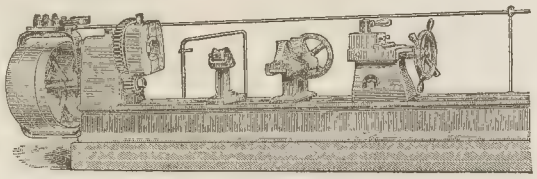


Fig. 134.

may clasp the axle by its collar when it is finished. The free end is held in an adjustable V-guide, and the end of the axle is squared and centered by a tool fed to it. The wheel-fit is sized exactly by a hollow reamer with adjustable blades. With these conveniences it is claimed that this tool and the lathe make it possible to produce from eighteen to twenty axles per man per ten hours.

With the lathes for axles should be discussed those lathes designed specially for finishing pulleys. Fig. 135

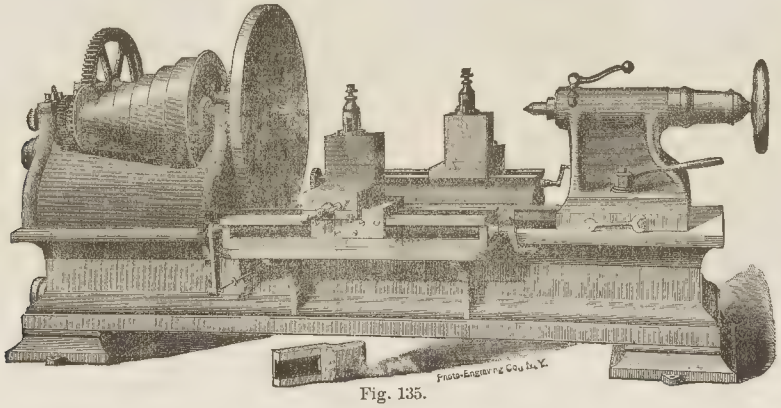


Fig. 135.

shows an ordinary lathe design of large swing, specially altered for pulley-work. The chief differences are in the use of two tool-rests of variable ratchet-feed, and in the arrangements to permit the face to be turned crowning.

Fig. 136 shows a special pulley-machine for taking bored pulleys on a mandrel. This system has the advantage over the chucking system of turning the pulley more under the same conditions in which it is afterward to be run on a shaft. The pulley is secured on the mandrel by its own set-screws or keys, although it is driven by driver-pins on the gear-wheel, resting against its arms. A former attachment will turn the face crowning. For filing or polishing the mandrel may be driven directly by the belt-wheel on the spindle.

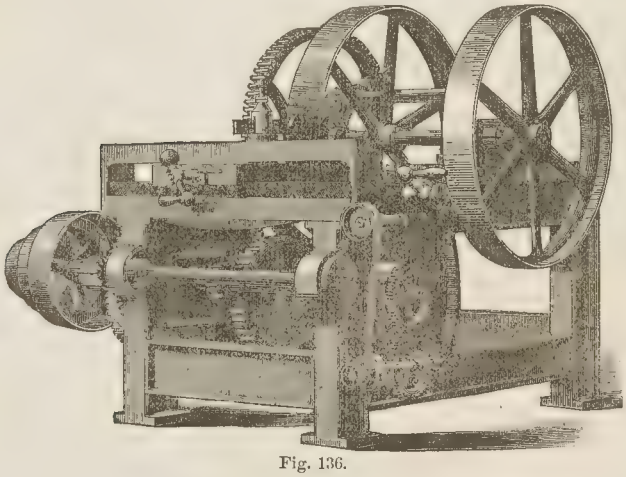


Fig. 136.

A similar tool is shown by Fig. 137, except that worm-gear is used to drive the mandrel, and the driver-pins are adjustable upon the face-plate to equalize the strain on the pulley-arms. The crowning is effected by setting over one end of the tool-post rail, according to the graduations. The worm-wheel on the feed-screw is relieved to permit this adjustment. The turned pulley is polished by securing it to the end of the worm-shaft, and the two operations of turning and polishing may go on at once.

Fig. 138 shows a double pulley-lathe on the mandrel system. The mandrel may be supported on a head with adjustable center, and the faces may be turned flat or crowning. Each slide has an independent self-acting feed, with automatic disengaging gear.

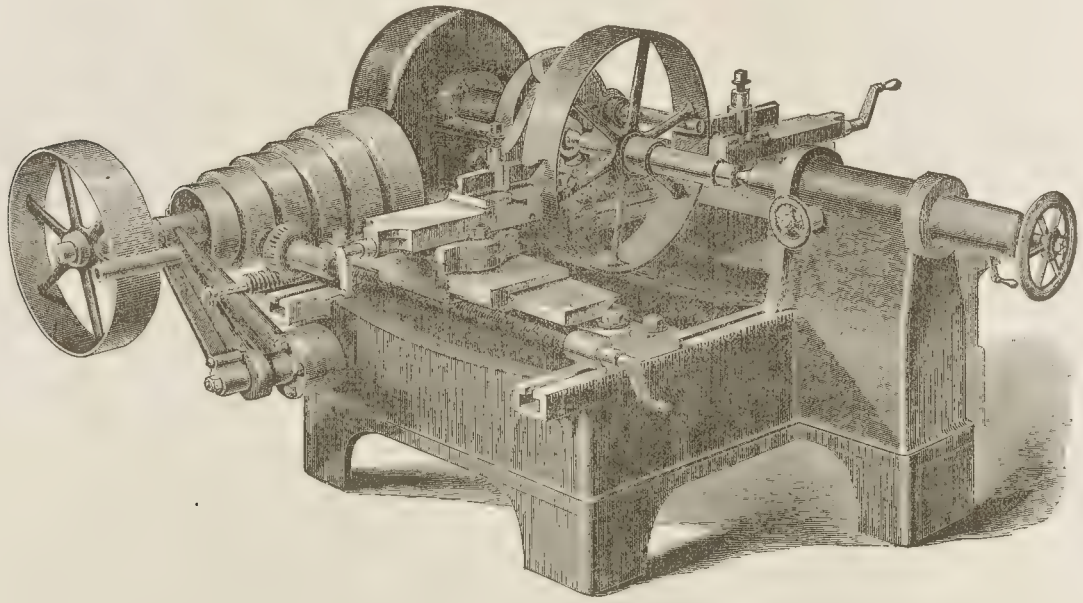


Fig. 137.

An objection to the mandrel system in these forms is that the pulley must first be chucked and the hole in the hub must be bored before the wheel can be put on the special lathe. This requires two tools, and some of the forms of boring-machine must precede the pulley-lathe.

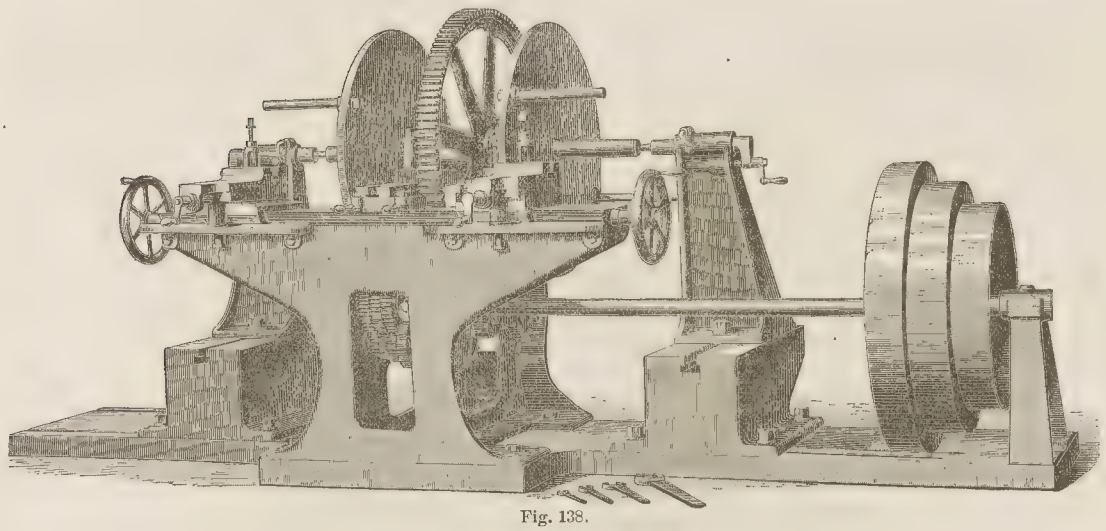


Fig. 138.

§ 18.

VERTICAL LATHES AND BORING-MACHINES.

The distinction between a lathe and a boring-machine is somewhat one of convention. Any lathe can be used as a boring-machine, either by securing the work to the chuck or by securing the work to the carriage and supporting a boring-bar between the centers. Especially is the distinction elusive when applied to the vertical machines. To carry out a possible analogy from the horizontal machines, a lathe would be a tool where the work revolved while the tool has only linear motions, while a boring-machine would be one in which the work was stationary and a cutting-tool described the surface of revolution. Many vertical lathes, however, on this classification are currently known as boring-machines, because they are designed for one class of work only, such as pulley or car-wheel boring-machines. There are certain of them which come unmistakably under the class of lathes, since they can turn as well as bore.

Fig. 139 shows one form of turning- and boring-mill. The work is secured to the horizontal face-plate and the tool is carried by the holder upon the cross-head. The feed of the tool is self-acting in all directions by the twisted belt at the right. The idle shaft, connected to the driving-shaft by a link, keeps the belt tight by its weight and permits the cross-head to rise and fall. The cross-head is only finished to guide the tool-post for a little over one-half the swing of the tool, since the cut is intended to be resisted by the compression against the cross-head. The slide on the cross-head is fed horizontally by the screw and vertically or at any angle from the splined shaft above the latter. The shaft carries a bevel-gear, which turns the rod parallel to the axis of the holder through an idle pair of bevel-wheels. As these mills have large capacity, swinging from 84 to 120 inches in the different sizes, the large face-plate must be steadied. This is accomplished by making a V-ring on the lower side of the plate which projects into and fits a corresponding V-groove in the bed. This makes the motion as steady as that of a planer bed. An adjustable step at the center can be made to take up any desired amount of vertical strain in the preliminary work of chucking and centering.

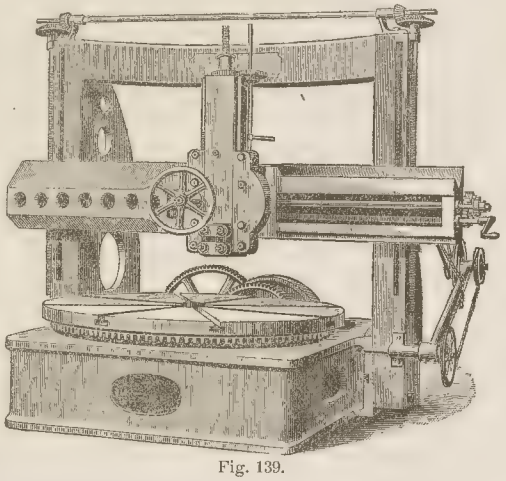


Fig. 139.

Fig. 140 shows a similar design, with two tool-holders. The holders are each counter-weighted by a weight on a wire-rope over pulleys. The rope winds on a pulley with a spiral groove at the back of the holder, the circumference of the pulley being in the axis of the holder. This prevents the action of the weight from departing very much

from the line of the action of gravity. The axis of the grooved pulley turns a pinion meshing into a rack on the side of the holder. The feeds for the tools are automatic in every direction and independent. The facing traverse is by screws which can feed in either direction. Their motion is received from the vertical shaft at the right, which

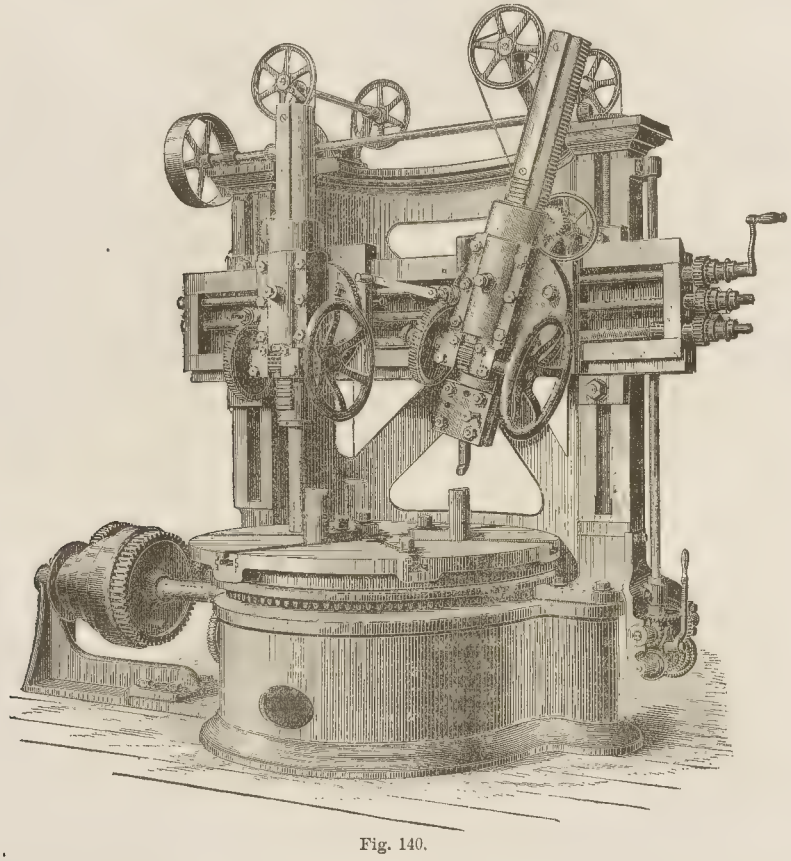


Fig. 140.

can be driven in either direction by the combination of three bevel-gears and a clutch from the cone-pulley shaft. Either cross-feed may be disengaged by a slip-jaw clutch on the end of the screw. For the downward and angular feeds the central splined shaft is used. A pair of bevel-gears, with clutch, is carried on the cross-slide. Between them is a third wheel, on whose shaft is a worm which turns a pinion-shaft and lifts and lowers the holder by a rack. The clutch to the worm-shaft is worked from behind the cross-head for change of direction, and the pinion-shaft is disengaged for convenient hand-feed and quick return by a slip-jaw clutch. The face-plate on the large sizes is driven by internal spur-gearing (Fig. 141) to avoid the lifting or bending action produced by bevel-gearing. The entire revolving weight is borne upon a central step. This consists of a loose steel disk, hardened and ground, which is placed between two others of a hard alloy of copper and tin. One is fast to the foot-step, and the other is on the revolving spindle. These disks are grooved for the distribution of oil, delivered through a tube under the center. Chips are kept from the lower bearing by guards. By the use of two holders a piece of work may be exposed to two operations at once. A pulley may be faced and bored at the same time, or a ring may be turned and faced at one operation. In another design the down-feed is given by a worm and wheel in front of the holder. The worm is driven by extensible shaft and universal joints for turning tapers. These tools are also made up to 12 feet swing. Some of the smaller sizes have the face-plate carried on a Schiele anti-friction curve, and a slotting attachment may be added for pulley-work.

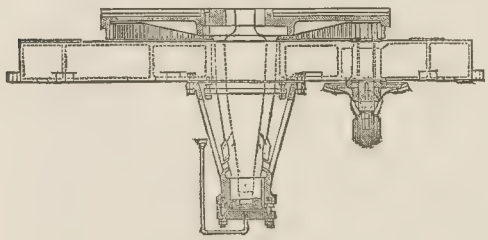


Fig. 141.

A similar tool to the latter is shown by Fig. 142. It has the adjustable step for the spindle, controllable by the screw in front of the bed. The feeds are made variable in speed and direction by the brush-wheel combination at the right of the bed. The movable wheel is faced with leather, and adjusted by the hand-wheel. The tool-bars are counter-weighted, so as to have the pull of the weight always in the line of the axis without oblique stress on the guides. For pulley-work the adjustable driver-plate and carrier-pins are employed, and an adjustable dead-center is made use of. By setting the bars slightly oblique and feeding in opposite directions the pulleys will be

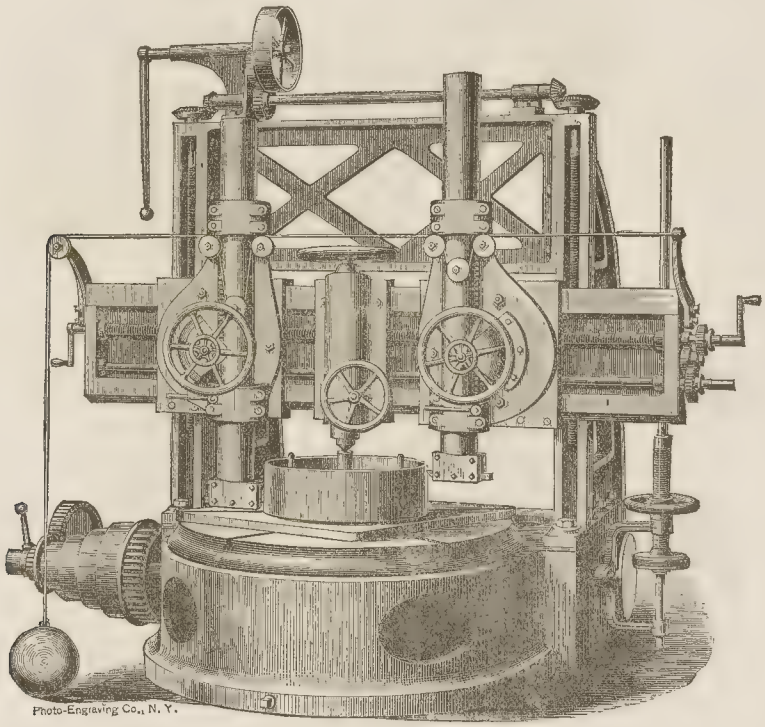


Fig. 142.

faced off with a crown. These tools are built of sizes to swing from 5 feet to 16 feet in diameter. In common with the other vertical lathes these tools have the advantage of simplifying the labor of chucking large and heavy work. All the time required to secure the work for the tests of its position on the face-plate is saved. The work will lie by its weight on the horizontal bed until located, while, when gravity has to be overcome on a vertical plate, the piece must be bolted fast. This property, with the conveniences of the double tool-bar, makes these tools of very wide and general usefulness. By removing the uprights of a very large mill of this class it may be used as a fly-wheel lathe for the largest diameters. The tool is held on a special upright on a floor-plate, and is fed by hand. Many drawbacks of the old chucking-lathe are thus avoided.

A very large number of vertical lathes of small swing are made for boring only and for special work. A type of these is shown by Fig. 143, adapted for boring-pulleys and car-wheels. The stiff boring-bar, counterpoised overhead, is held in the long adjustable bearing. It is fed downward by rack and pinion, driven by worm and wheel. The hand-feed quick-return is released by a friction-clutch. Specially for car-wheels the same builders have the tool shown by Fig. 144. The crane attachment is very convenient for chucking rapidly. Such tools are made with chucks of the self-centering and independent-jaw variety. They have capacity for wheels of 42 inches diameter.

Another form of car-wheel boring-machine is illustrated by Fig. 145. The adjustment for the bearing of the bar is effected by tightening the bolts upon the split casting. The counterpoising of the bar is by means of the weighted lever, which has a floating fulcrum to avoid side strain. The face-plate is adaptable for boring tapers, for the few conical fits which are used by some. It is made of two disks, the faces of both being beveled as they lie together. By changing the relation to each other of these two disks the horizontal adjustment is destroyed and a conical hole is bored. There is also a hub-facing attachment. The boring-mill of Fig. 146 feeds the tool down by a different mechanism. The hub-facing attachment has a slide independent of the boring-machinery, so that a

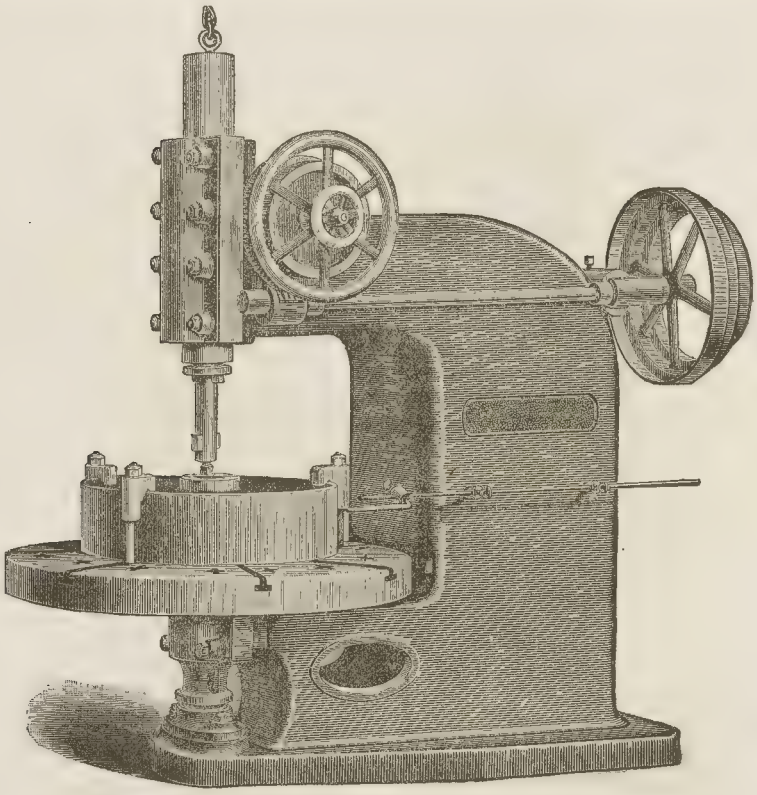


Fig. 143.

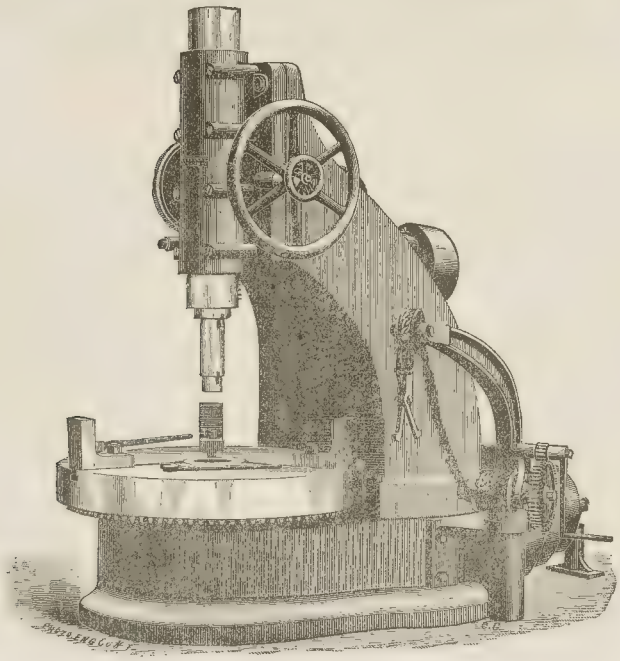


Fig. 144.

hub may be bored and faced at the same time. The crane attachment for lifting the wheels is hung from a davit overhead. It is a geared hoist. This machine has a claimed capacity for fifty wheels per ten hours.

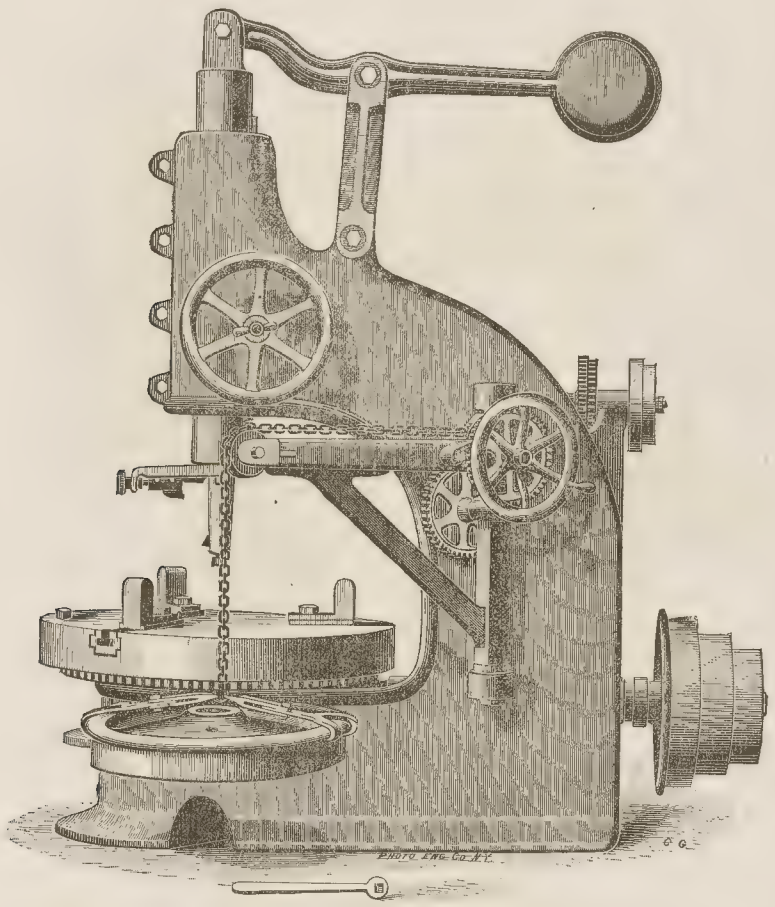


Fig. 145.

The borer of Fig. 147 takes up any lost motion around the bar by the glands at the top and bottom of the long bearing. These compress centrally a conical split sleeve when tightened down. The face-plate is carried upon a Schiele curve bearing, with a shoulder and ring at the top to prevent lateral jarring. The feed is by rack and pinion through worm-gear, engaged by friction. The gears are all external but boxed from dirt and accident. The roughing cut which should size to within $\frac{1}{32}$ of an inch is made with a feed of $\frac{1}{4}$ of an inch. The finishing cut is made with a feed of $\frac{3}{8}$ of an inch. By this machine a wheel can be chucked and bored in four minutes, as against seven minutes in the previous forms. The lifting-crane is also driven by power at the back.

For smaller work than this the table-borer (Fig. 148) is in use. The boring-bar is steadied and held by a counterpoised cross-head below the table. The feed is varied in either direction by the friction-disks between the desired limits, exactly as in the lathes of the same builders. The objection to these disks is their tendency to wear into rings, because of the sliding action where they overlap. All the borers of this type use the double cutters wedged into a slot in the bar (Fig. 149 *a* and *b*). The roughing-cutters wear more rapidly of course than those used for finishing. The first will probably lose its edge after boring four or five wheels; the other will last for more than ten times that number.

In all these forms of tool the horizontal chuck-plate permits very rapid adjustment of the wheels in place. Light hydraulic cranes are sometimes arranged to accommodate a number of tools, without requiring a special one for each.

For the boring of large vertical cylinders large shops usually have an especial apparatus, put up most frequently in a corner. A heavy boring-bar carries a spider or tool-carrier, which is moved up and down by a

screw in the deep spline which compels the rotation of the carrier (Fig. 150). A large gear drives the bar and the carrier-head, and reducing gearing feeds down the screw. Sometimes the feed-gear is driven by an epicyclic

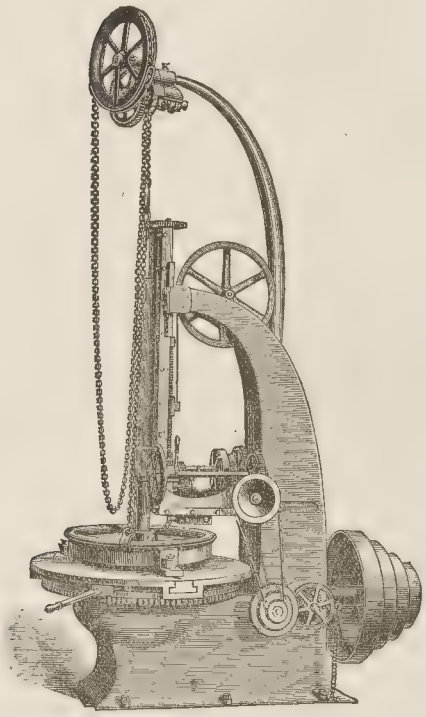


Fig. 146.

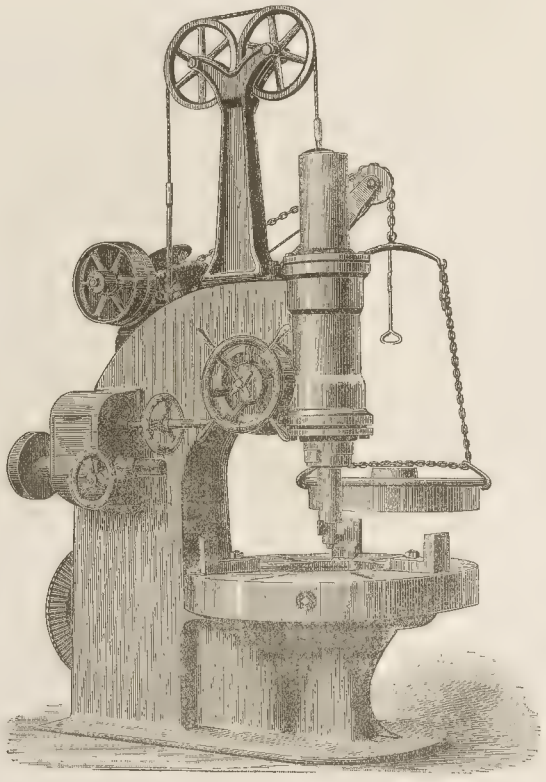


Fig. 147.

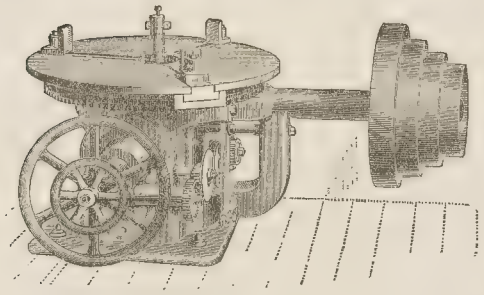


Fig. 148.



Fig. 149 *a*.



Fig. 149 *b*.

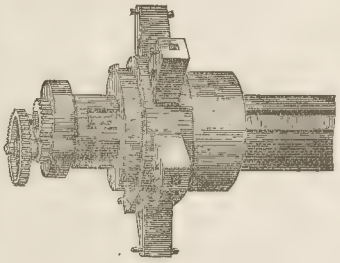


Fig. 150.

train. The cylinder is dogged and braced to a floor-plate at truly right angles to the bar. These machines have capacity for the largest cylinders.

§19.

HORIZONTAL BORING-MILLS.

The horizontal mills are especially adapted for bar-boring, either between centers or in bearings. The work is dogged to a table or carriage, which may be automatically fed or not, the feed in most cases being on the cutter-bar only. This type of tool is especially adapted for work in which the axis of the hole to be bored is parallel or not perpendicular to the chucking surface. It therefore lends itself easily to the boring of journal-boxes and hangers, of horizontal cylinders for engines and pumps, of elastic cylinders, and of cylinders without flanges, and work of that class.

For bar-boring between centers the machine of Fig. 151 is a type. The live-spindle is strongly back-geared,

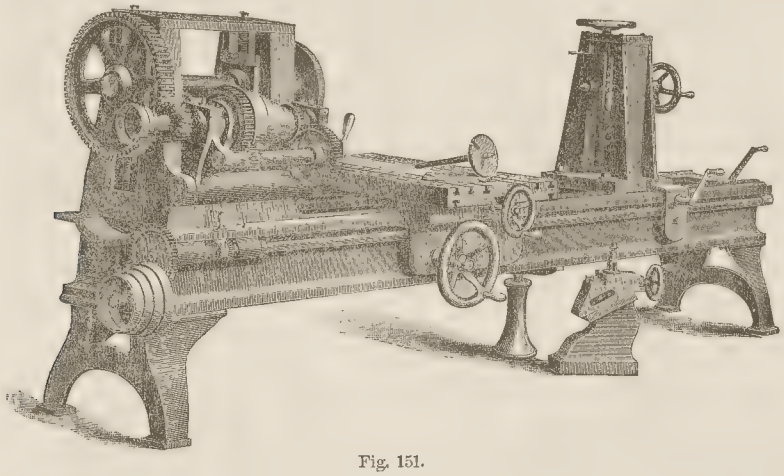


Fig. 151.

turning in long bearings at each end. The bearings of both head- and tail-stock are lifted by screws geared together by bevel-gears to a longitudinal shaft under the shears.

This arrangement insures that the two centers shall always remain in line. The hand-wheel at the dead-center permits accurate adjustment. The carriage is compound, having a longitudinal motion in either direction by power, and a cross-feed by hand. The power feed is reversed by a clutch between two bevel-gears. In some forms of this tool, when using a compound boring-bar, the carriage and work are stationary and the feed of the carrier is moved by a star-wheel on an arm from the head of the bar. Like any boring-mill with centers, this tool can be used as a lathe by simply bolting a tool-post to the slotted carriage; and conversely, of course, any lathe can be used as a similar bar-boring mill. This tool has the advantage over the lathe, in that the work does not have to be blocked up into the axis of the centers. The work can be bolted to the carriage, and then the centers can be rapidly adjusted into place.

For bar-boring in journals, and for horizontal drilling, the type of machine shown in Fig. 152 is used. A column supports a head like a lathe poppet-head. The spindle is long and has a longitudinal traverse. It is heavily back-geared, and is fed forward by a screw driven by friction-disks. This permits wide variation of feed for holes of different diameters. There is also a hand-feed over the spindle. The front end of the spindle is bored tapering, and can receive either a drill or the end of a boring-bar. The table in front is carried upon screws which are moved together by a hand-wheel convenient to the operator. The carriage has a longitudinal traverse, by a screw moved by the second hand-wheel, and also an adjusting cross-traverse. For the use of a boring-bar, an adjustable bearing to steady its outer end may be clamped on the carriage. More frequently, however, when bar-boring is to be done, the yoke-system is preferred (Fig. 153). The hole in the top is in the center line of the spindle, and can be bushed for different diameters of bar. It can be bolted to any part of the bed-plate for different lengths of bar, and also serves to steady the free end of the table. The front of the column carries the long gibbed knee of the table, giving great stiffness when at work. The thrust of the spindle is taken up at the collars which embrace the bracket at the back. This bracket is guided at its foot, below V-guides, and is fed forward by a rack. This rack is driven by a worm and wheel, which is engaged with the hand-feed and quick-return by a friction-clutch. There are six changes of feed, three of which are for drilling and three for boring. The slowest feed will permit small holes to be drilled in steel; the fastest gives $\frac{1}{4}$ of an inch feed for finishing cuts in boring. The cut shows

the raising and lowering gear driven by power. The tool may be run forward and backward at the same speed, so as to cut in either direction with the same cutters. The back-gear is compressed for ease of handling and compactness.

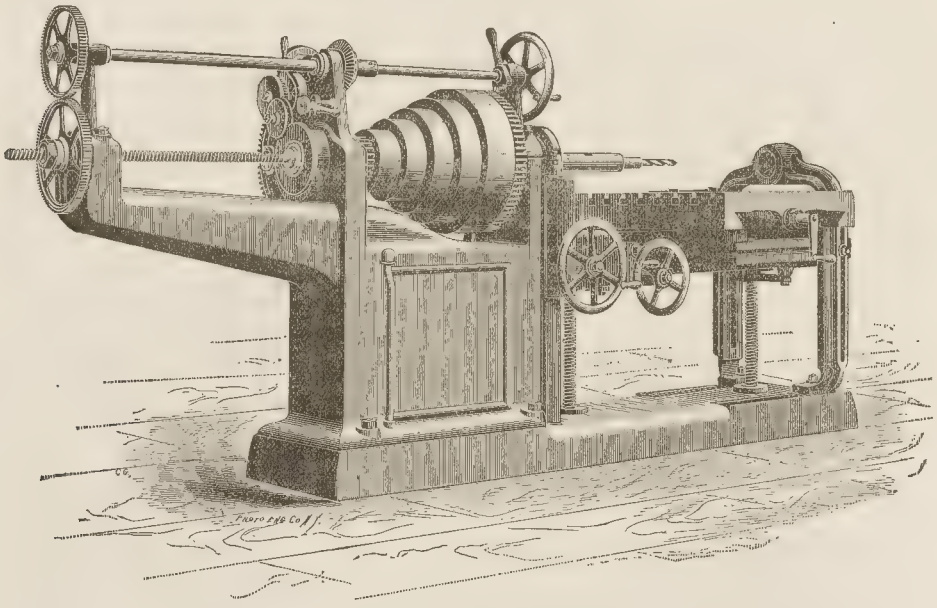


Fig. 152.

Fig. 154 differs only in the arrangement of the feed-gear. On one of the shafts are three loose gears. Each has a keyway cut in it. On the shaft is cut a spline till it meets a hole in the axis, in which slides a rod from the end. A key, fixed to the end of this rod, may be moved along the cut spline so as to come opposite the key-way in any of the gears, when it will slide into it, and make that gear fast to the shaft for the time. There is also a

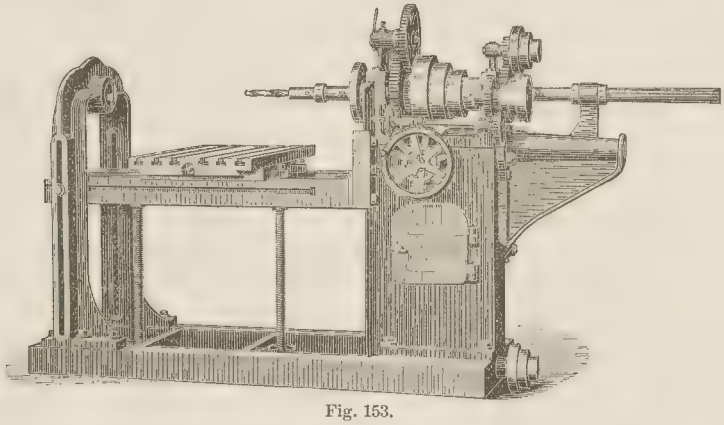


Fig. 153.

slow hand-feed and quick return. A facing-rest may be bolted to the face-plate, and will be fed by the star-wheel. The driving-pins are lightly bolted to the top of the head-casting. The thrust is taken up as before by collars against an arm from the guided slide, but in this design the arm is quite short. Sometimes a tail-screw is arranged on the slide to take up lost motion and to receive the thrust.

Where the work to be bored or drilled is very large or heavy, it is convenient to bolt it to the floor and to move the live-spindle into the proper position. Such a design is illustrated by Fig. 155. A large floor area is covered by a sole-plate with intersecting T-slots planed in it. In any position on this plate may bolt the lower

block of the spindle upright. The upright has an adjustment laterally on guides upon this block for distances less than the intervals between the slots. The spindle may be clamped at any elevation above the plate within

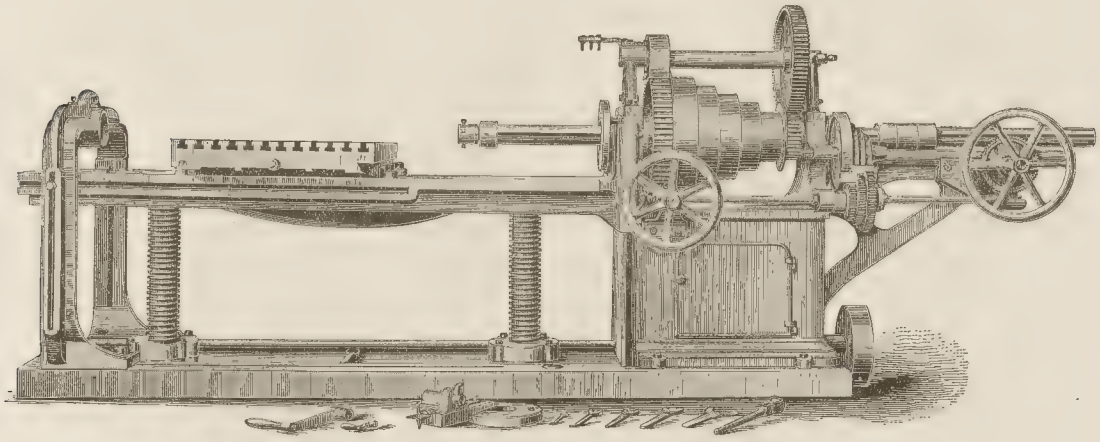


Fig. 154.

the limits of 6 feet 4 inches, and 14 inches. The casting is raised and lowered by screws driven by power. The power is transmitted to the tool by belts from swinging frames to take up the slack of adjustment. The bar is fed by a screw driven by friction-disks. To support the outer end of the bar a similar. but smaller, upright may be used, bolted to the slotted table where needed.

Another tool, with greater vertical capacity but less convenient horizontal adjustment, is made at Providence, Rhode Island. A tall upright, 15 feet high and braced from the roof, carries the gibbed slide with the horizontal

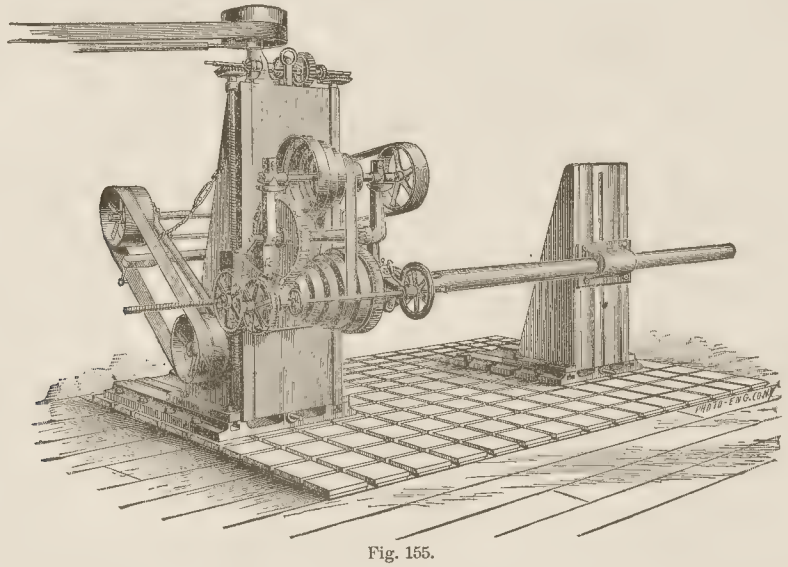


Fig. 155.

driving-spindle. Motion is imparted to the spindle by a pair of brass bevel-gears, the vertical shaft being splined and moving upward with the slide. The spindle is made long, and the thrust and feed are provided for by an arm from a guided slide. The feed is by hand and power, the adjustment of the slide being only by hand. Its weight is counterpoised. To secure the work a heavy table moves transversely on rails, the adjustment being effected by a pinion in the table taking into a fixed rack on the floor. There is no outer support for a long bar at high levels. The machine is more used for drilling, or for boring with short tools held in the end of the spindle.

A special tool for boring and facing flanged cylinders for locomotives and other engines is shown in Fig. 156. A 6-inch steel boring-bar is driven at both ends by the face-plates from a splined shaft in the bed. The bar can

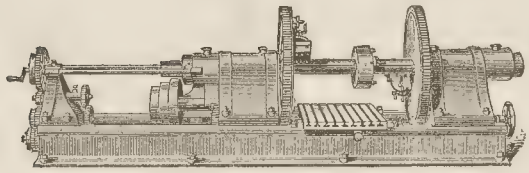


Fig. 156.

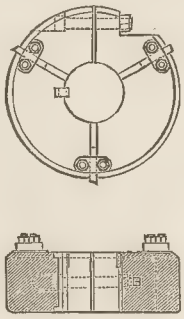


Fig. 157.

be withdrawn from the work by hand or power, and the cutter-head may be similarly fed in at the proper speeds for the heavy rough cut and the finer finishing cut. Facing-rests bolt to the two face-plates so that the sinking head may be cut off and the flanges faced up while the roughing cut is in progress. This arrangement gives truer

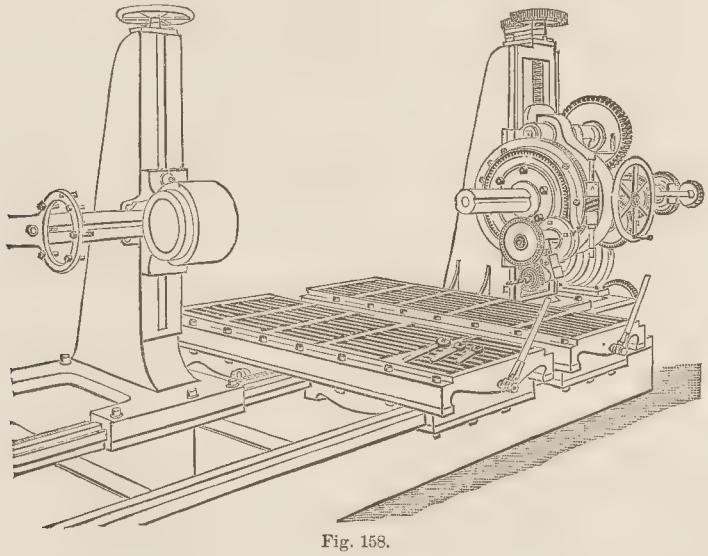


Fig. 158.

work than when the facing-tool is driven from the bar, since the variation in resistance will cause a springing of the joints in the latter case. By this machine the time for boring and facing a locomotive cylinder of usual dimensions has been reduced to a little over one-third of that required with less perfect machines. The boring-head for these bars is made to clip the latter (Fig. 157). The head is cut at one element, and is held by a bolt, which clamps firmly and yet can be instantly released.

A similar tool, designed for large horizontal work, is shown by Fig. 158. Beside boring and facing cylinders of large size, by this machine the holes in the flanges for the cover-studs can be drilled. The whole live-spindle head can be raised and lowered by power, and the post is arranged with a bracket bearing which will support the outer end of bars of different diameters by means of inserted bushings. Its longitudinal and vertical adjustment are effected by screws. The flange-drill E is revolved around the center of the spindle by the worm A′ and held in place by it. By this system the holes can be adjusted to be on the circumference of any circle around the axis of the cylinder and can all be spaced equally.

Fig. 159 shows a third upright with a longitudinal and transverse motion beside the vertical adjustment. This head is used for surfacing work. The tables have compound motion. The bed of this machine is 39 feet long.

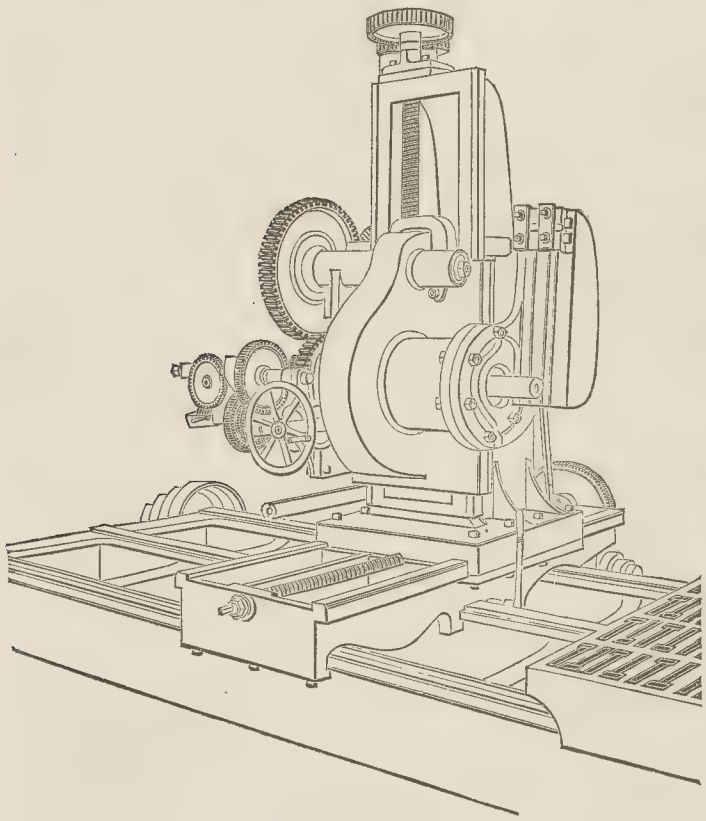


Fig. 159.

§ 20.

DRILLS.

The distinction between drilling-machines and boring machines is not very marked with respect to their function. Usually, however, the drill cuts only at the bottom of a hole in the solid metal, while the boring-tool cuts at the side or bottom of a hole already made. It is possible in the case of most large holes to have them either punched or cored, whence their enlargement to exact size will be effected by boring. Drilling will be usually resorted to for small holes. A drill will, therefore, turn more rapidly than a boring-machine, and will usually be a much lighter and smaller machine.

The question of feeding the drill-point forward against the work was for a long time debated. Some held that it was unwise to have power-feeds; others approved them. Practice of to-day favors a disengageable feed from the spindle, permitting a quick-return by hand, or a hand-feed if desired.

The prevailing drill properly so-called has its spindle vertical. The motion from the horizontal shafting of the shop must, therefore, be transmitted to the spindle through a pair of bevel-gears or else by belt over guide-pulleys. The bevel-gear combination is in the majority. The work will be secured to a T-slotted floor-plate under the spindle, or to a table, according to its size, and according to the type of machine.

The drill-presses may be variously divided, according to their form. For convenience they will be discussed under the heads of upright drills, radial or column drills, and other forms. The latter will include such types as the suspended and multiple drills and special designs.

§ 21.

UPRIGHT DRILLS.

The upright drills (so-called) are usually made to be self-contained. The counter-shaft, with fast-and-loose pulleys and the nest of cone-pulleys, is put at the back of the machine and conveniently near the base. This position of the cone-pulleys makes the shifting of the belt quite easy. The horizontal driving-spindle will be at the top of the machine, both being carried in journals which are on brackets from the main upright of the tool. There are two types of practice with respect to the manner of securing these brackets. Some designers cast the upright and brackets all in one piece. This type is called a "gooseneck" drill, and is illustrated by Figs. 162, 167, and 168. It has the advantage of stiffness and cheapness of fitting. The other type has the brackets bolted to flat seats made for them. By this means is avoided the risk of failure of an entire large casting because of defects of small parts of it.

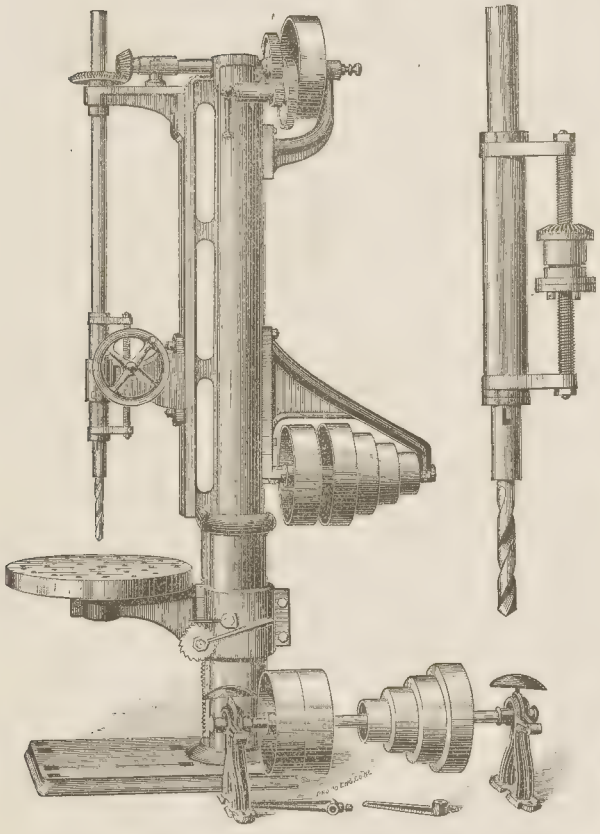


Fig. 160.

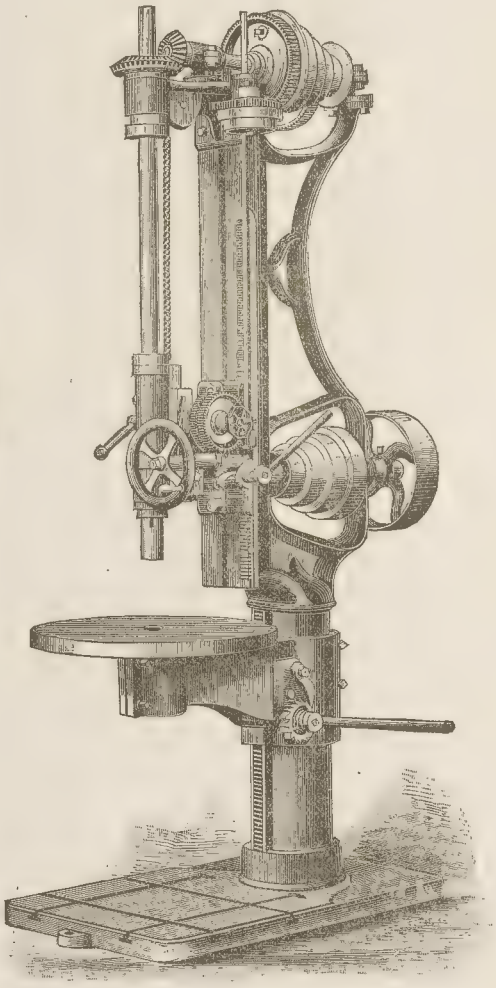


Fig. 161.

A type of this design is shown by Figs. 165 and 170. Upon the lower part of the principal upright a cylindrical surface is turned. Upon this fits a bracket, very usually split so as to clamp in place, which carries the table. This table is made with slots and T-holes in it for securing work, and its top surface must be truly horizontal when the tool is in place. This table is made to raise and lower by a pinion meshing into a rack. This pinion will be turned directly in lighter tools by a crank or ratchet-lever, or indirectly by a worm and wheel. One form uses

a worm (Fig. 167) meshing directly into the rack whose teeth are inclined to conform to the obliquity of the screw. This rack is not cast on the cylinder but fits between collars at top and bottom of the turned surface, and is kept in its vertical position by its fit through the knee. By this expedient, not only is the fitting of the table made more easy, but the table can be made to swing around the upright out of the way of the spindle, if desired.

The foot of the upright rests in a foot-plate in a long, deep socket. In newer practice this foot-plate is planed and slotted to secure deep work to, that it may serve also as a table. The table is usually held in the bracket by

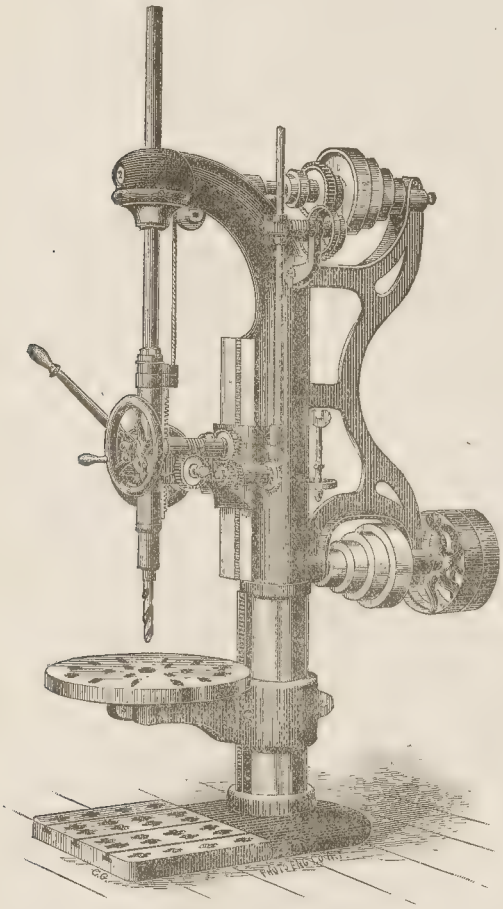


Fig. 162.

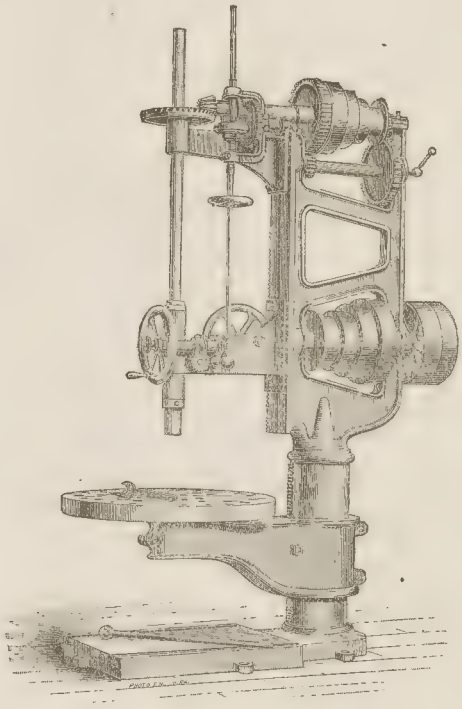


Fig. 163.

a clamp, taking hold upon a cylindrical post, on the lower side central and perpendicular to the finished face. Sometimes this post is screwed into the clamp-nut of the bracket, for finer vertical adjustment. Perpendicular to this table and to the planed foot-plate must turn the spindle of the tool. This is driven from bevel-gear on the upper spindle, the horizontal gear being usually the larger, that the belt-pulleys may turn at high speeds. The horizontal gear usually turns in the bearing in the upper bracket, being provided with a very long hub. This avoids the cutting and wearing of the bearing by the sharp edge of the spline. The vertical spindle must be splined to permit the motion for feed and for adjustment, while the driving bevel-gear remains stationary. The lower bracket, which guides the lower end of the drilling-spindle, is made adjustable vertically for work of differing depths. It is provided with a long knee, which clamps to a planed slide in the front of the tool. Where the bracket is not counter-weighted, the bracket is lifted by a pinion turning in a rack cast in the slide (Fig. 161). The newer types are arranged to move by the unaided hand.

Fig. 160 illustrates one of the older types with separate counter-shaft and hand-feed only. The feed was by a screw bracketed out from a sleeve through which the spindle passed. The sleeve only is fitted to the bearing in the bracket. At the bottom of the sleeve is the point at which the thrust of the cut is borne. Present practice

puts a brass washer, or a hardened steel washer, or a washer of rawhide at this point, and any lost motion or wear is taken up by different devices above the sleeve. In place of the screw, the practice of to-day favors a rack, usually cast as part of the sleeve and fed downward by a pinion, driven through worms.

Fig. 161 shows the rack and ratchet device for lifting the feed-bracket. This is made necessary by the fact that the spindle only is counter-weighted. It is of course more important to counter-weight the spindle in order that its weight may not be released suddenly if the drill-point enters a blow-hole. The edges would be likely to catch,

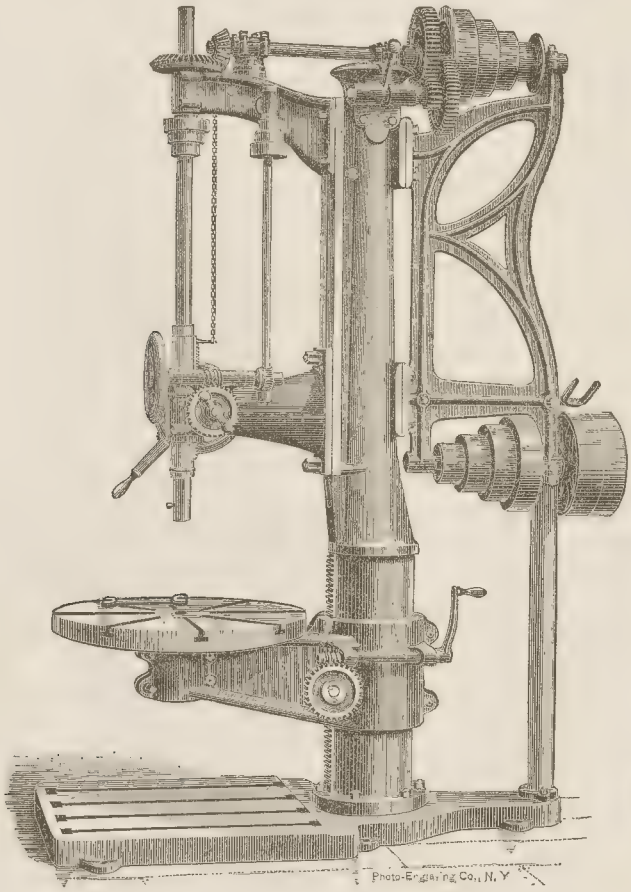


Fig. 164.

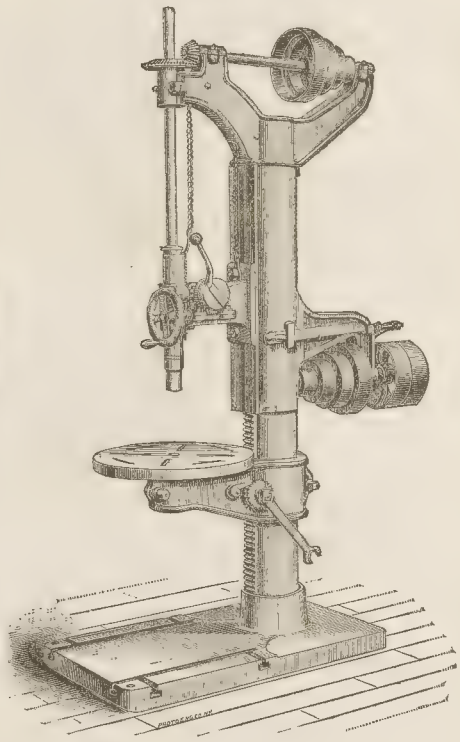


Fig. 165.

and the drill would break. The power-feed is from cone-pulleys on the hub of the horizontal driven bevel-wheel, which drive a splined worm-shaft by reducing gear. Hand-feed through a second worm is disengaged by friction, and a quick-return lever, for use when both are thrown out, is on the farther side.

Fig. 162 shows the typical gooseneck drill. The counter-shaft is on the back of the tool, and the bevel-gears are incased from dust. The feed changes are made without shifting the feed-belts by shifting-splines on the movable bracket spindles. The hand-feed and quick return are engaged by friction. The counter-weight hangs in the column.

Fig. 163 shows a drill of 48 inches swing, fitted with a variable power-feed by a brush-wheel combination. The power is gained by two worms. The hand-feed is disengaged by friction.

Fig. 164 shows a counterpoised spindle design. The rear post is introduced to stiffen the frame against the thrust of the cut. This flexure of the upright is one of the great defects in the single upright system. The same drill illustrates the lifting of the table by worm-gear.

Figs. 165 and 166 show a counterpoised drill in which the quick return and hand-feed are original. The bent lever swings on a pivot in the diameter of the disk, and a tooth on the end of the rectangular part may catch in notches in the face of the worm-wheel. The power-feed may be disengaged by a friction-clutch.

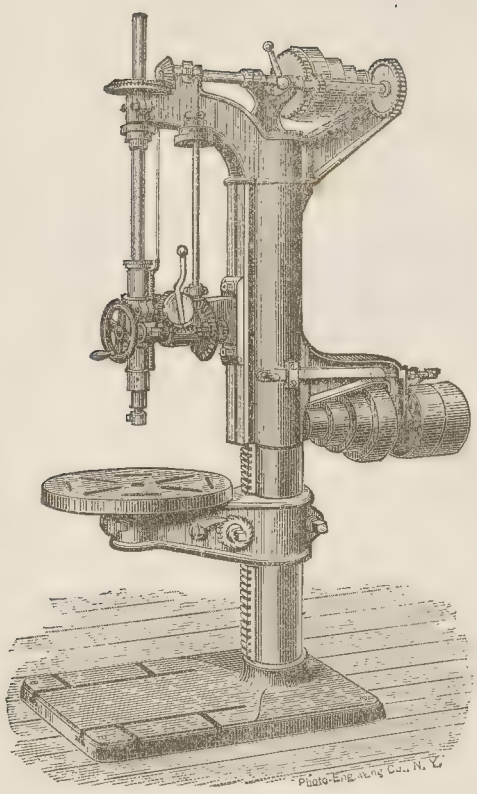


Fig. 166.

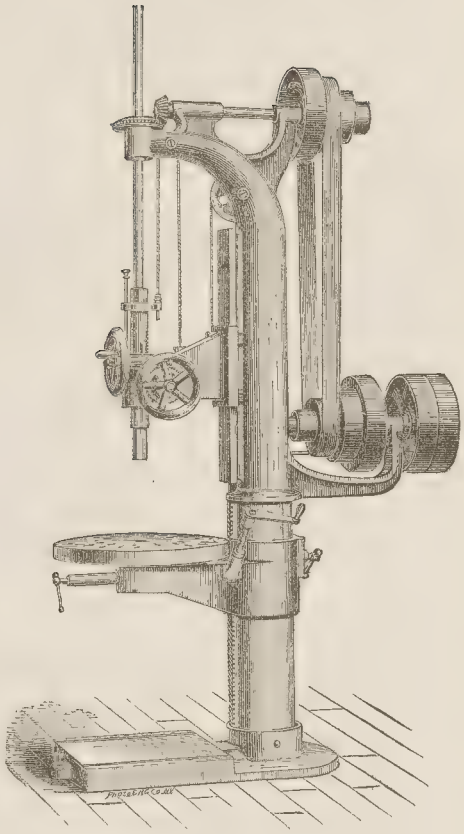


Fig. 167.

Fig. 167 uses but one weight to counterpoise both spindle and bracket. The wire rope is continuous, and passes under a sheave in the bracket from over pulleys in the upright. There is also an adjustable depth-gauge attached to the lower stock. This is an accurately graduated scale, which enables the operator to determine the penetration of the drill by an index on the feeding-sleeve.

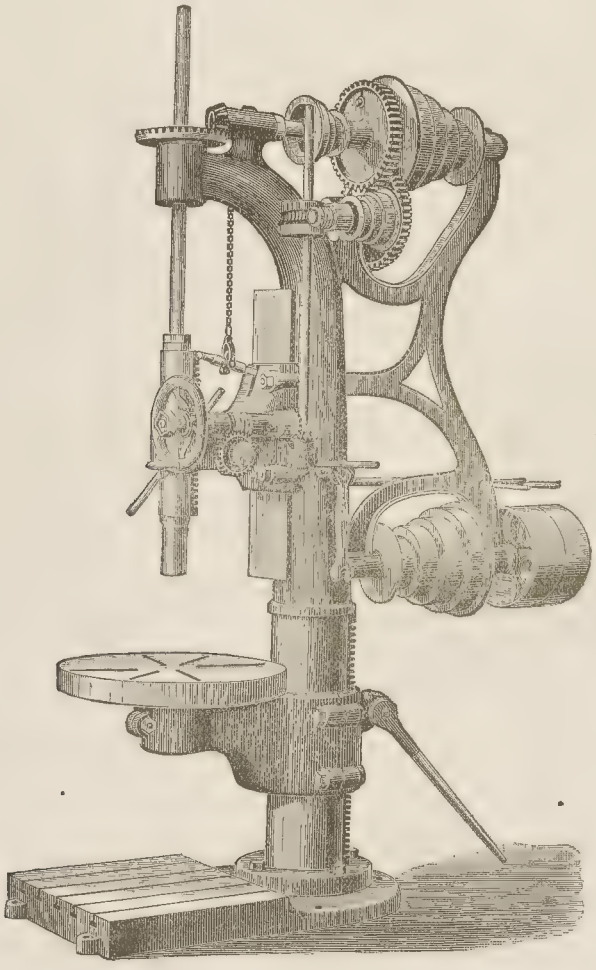


Fig. 168.

Fig. 168 shows a New England design where one weight counterpoises both spindle and bracket. The chain lifts both by a hinged lever, attached to the bracket near its center of gravity by a link. This link compensates for the motion of the spindle, and the adjustable clamp of the clevis D permits any proportion of the counter-weight to be distributed upon the spindle joint as the weight may vary in the socket. The power-feed and quick-return are controlled by friction-clutches. This tool also illustrates the compacting of the back-gear mechanism upon a short axis. This is very general in the newer tools.

Fig. 169 illustrates the same arrangement of back-gear, but the spindle has but one long bearing instead of two. The table has a very long vertical adjustment by a screw let into a slot in the column. The brass nut of the screw can be disengaged by the pin below the table in front, so that the table may swing aside. The changes of feed are accomplished by the three bevel-gears on the worm-shaft. The vertical gears are engaged with the geared spindle by a movable spline operated by the rod and milled head at the rear end. The counterpoise is annular over the top of the spindle-cap.

Fig. 170, by the same builder, illustrates the bolted system for the upper brackets.

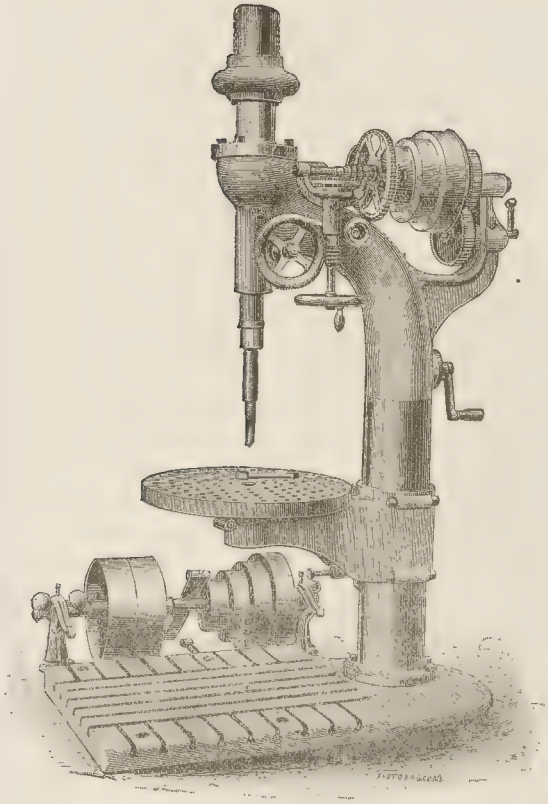


Fig. 169.

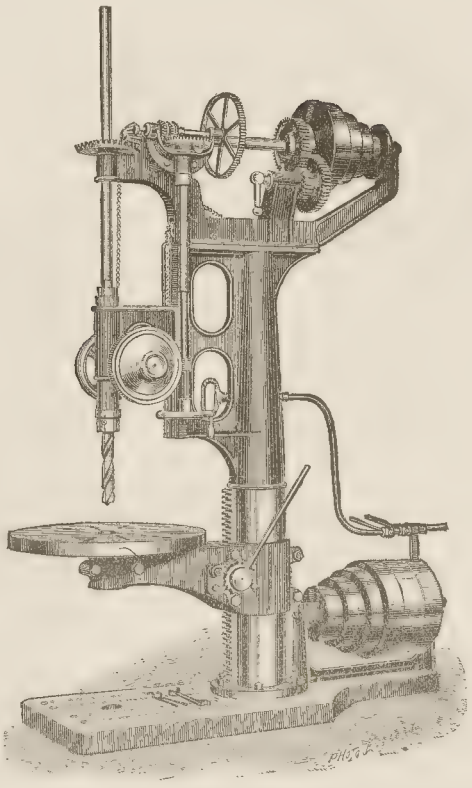


Fig. 170.

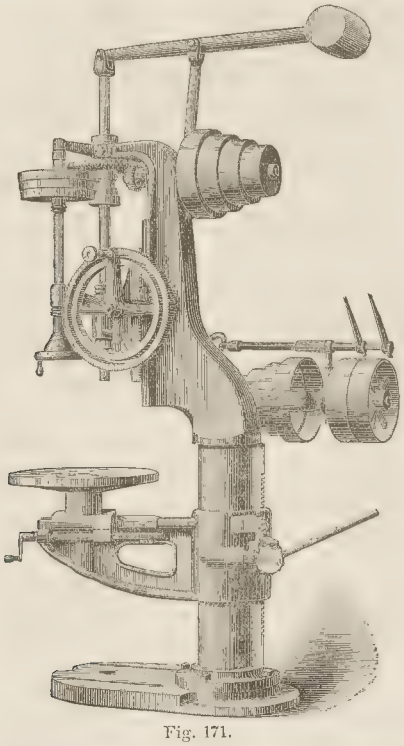


Fig. 171.

Fig. 171 shows a lever counter-weight drill, with the feed driven by a cone of belt-wheels. The hand-feed and quick-return device is by a frictional clip in the sunk ring of the worm-wheel. The handle of the crank forms a screw-clutch. The table has a horizontal traverse by screw.

Fig. 172 shows a lever counterpoise drill, the links being curved so that the short lever may not cause binding upon the spindle. The quick-return is by a lever on the left-hand side, the worm of the feed-motion being moved laterally away from the pinion wheel by an eccentric on the vertical rod at the right. The power-feed has three

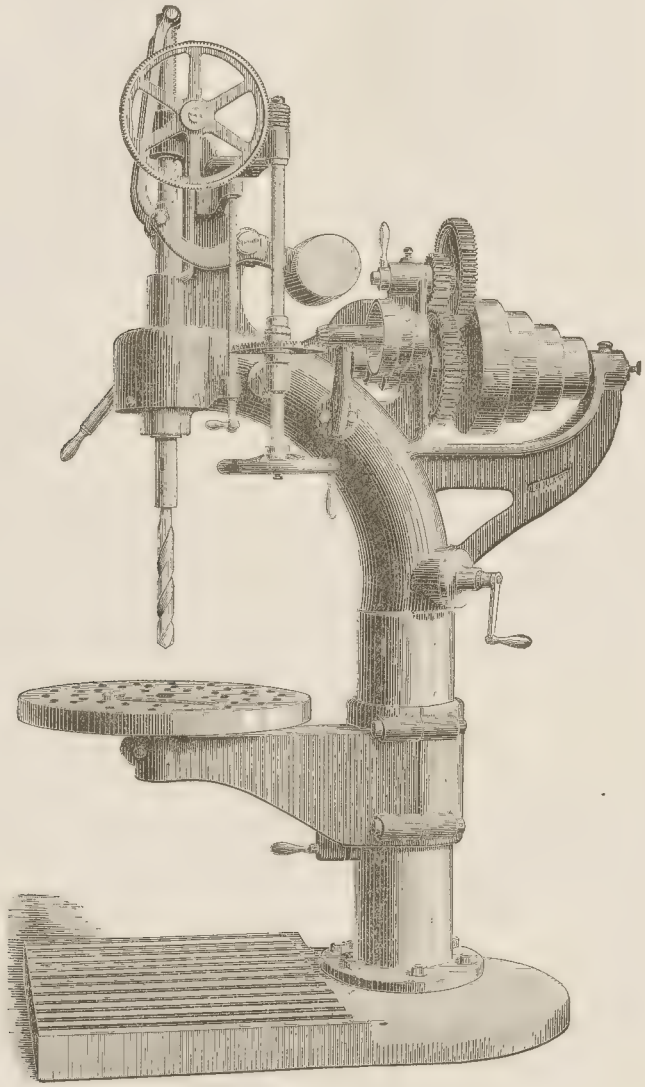


Fig. 172.

changes by a belt cone, the horizontal gear being disengaged for hand-feed by a jaw-clutch. This is lifted by the rod, in the axis of the worm-shaft, by the milled button below.

Fig. 173 illustrates a type of drill in which the spindle may be driven by belt only, when the back-gearing is not required. The belt passes over guide-pulleys, on the back of the square upright. The direct use of a belt gives a smoother running for very small drills. The feed is by a screw of steep pitch engaged by a clutch worked by the latch-lever. The thrust is borne on the very long nut of the feed-screw. The table is gibbed to a flat slide in front of the upright, but by loosening two bolts the table is released and swings to one side. The axis of the swinging of the table is the lifting-screw, which is at the left side, and is turned by power. The power for this motion of

the table is obtained by clutching a horizontal internal shaft with bevel-gears. The clutch is worked by the lever near the base of the upright, and access to the gears is had through the small door. The table has screw traverse in both directions, which is often found a great convenience in miscellaneous or spaced work.

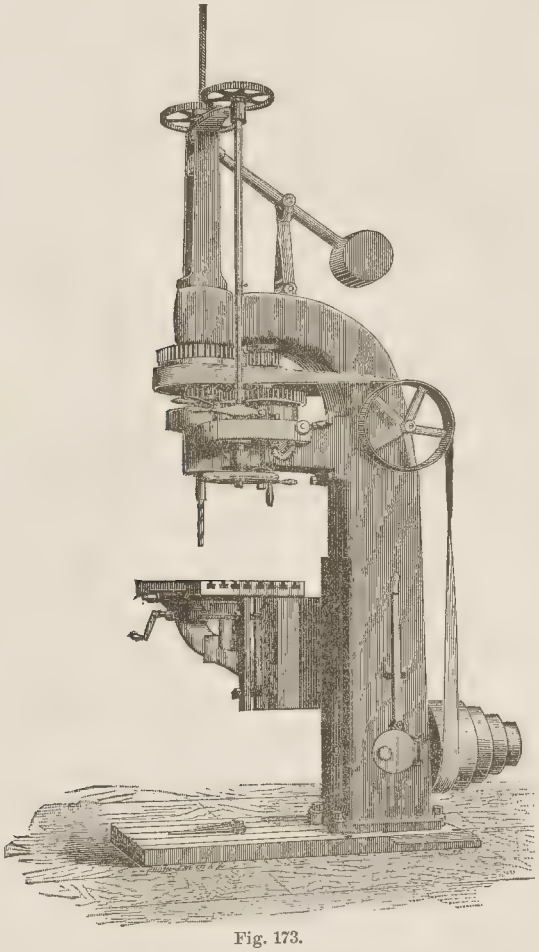


Fig. 173.

§ 22.

RADIAL OR COLUMN DRILLS.

This class includes those in which the carriage bearing the drilling-spindle is adjustable upon a horizontal arm, which swings cranewise around a vertical column. The drill-point can therefore command any point in an annular area, determined by the outer and inner swing of the radial arm around the center of the column. A tool of this sort is especially adapted for heavy work, inasmuch as the drill can be moved to any point of the work more easily than the work can be adjusted under the point of the drill. Moreover, the swinging of the radius permits the drill to command a variety of tables of different levels.

Such a tool is illustrated by Fig. 174. The radius arm is double, to give firm bearing on both sides of it for the spindle-carriage, and has a long internal bearing from the collars upward. The radius is clamped in place by the split in the sleeve at the collars. There is a slotted floor-plate, a tilting-table, adjustable by a screw and clamp, and on a third side may be a pit, if desired, to work on the ends of very long pieces. The tilting-table permits the drilling of angular holes, and is preferred by the builders to the use of an inclined spindle. The tool is driven by a central vertical shaft from a cone-pulley shaft below. A splined shaft takes off the power in any direction from the bevel-gear on the top. The carriage travels over the radius by a rack and pinion from the hand-wheels, and the

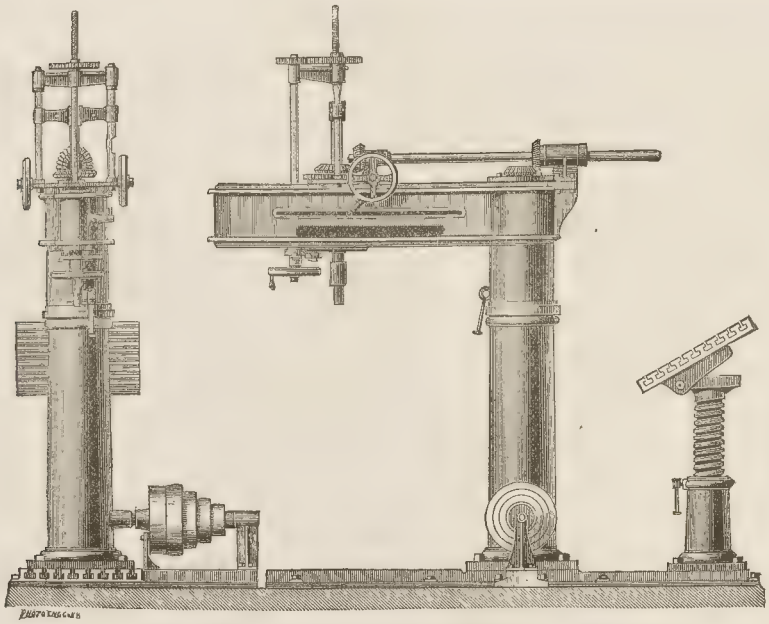


Fig. 174.

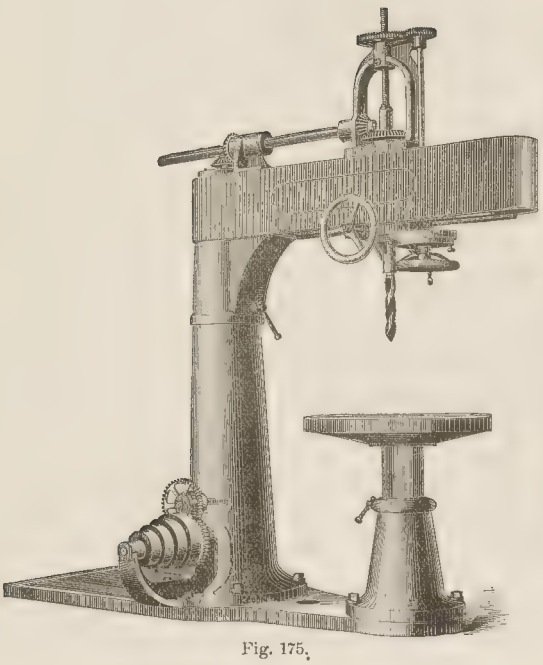


Fig. 175.

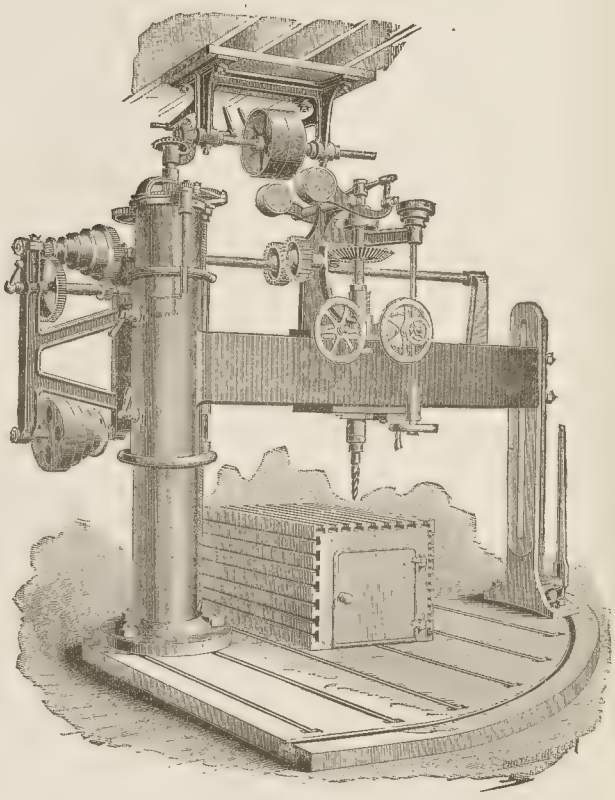


Fig. 176.

tool is fed downward by a screw. The back-gear connection is very compact. Fast to the large pulley of the cone is a small gear. This meshes into a second whose stud is carried by an arm fast to the spindle. This arm is counterpoised on the other side of the spindle, and by this sector the arm can be locked to an internal wheel with which the idle gear is always engaged. When so locked the spindle will turn with the cone. When the internal wheel is locked to the base-plate of the drill and the sector is released, the arm will be carried around as the idle-wheel rolls on the internal wheel, and the speed will be much reduced.

Fig. 175 illustrates a very similar design.

Fig. 176 shows a design intended to increase the vertical capacity of the tool, by making the whole radius move vertically upon the column. This enables the tool to act easily upon very flat, heavy work. The lifting-screw is driven by power from the central shaft, engaged by the lever motion from the handled rod. This tool also avoids a difficulty which results from the overhang of the radius when heavy cuts are made. A slotted post, moving on the arc of the end of the radius, may bolt the latter to the bed, when the tool becomes as rigid as could be desired. The spindle is driven by a pair of gears from the splined shaft, which may be driven directly or double geared. The feed is from cone-pulleys to a worm and wheel, disengaged by friction for hand-feed.

Fig. 177 shows a similar design, where the drilling-spindle is universal, and holes may be drilled at any angle. The spindle is driven from the splined shaft, below the radius, by two pairs of bevel-gears, the axis of the idle pair being in the center of the swivel clamp-plate. The tool is driven directly from a horizontal belt, and the arm is

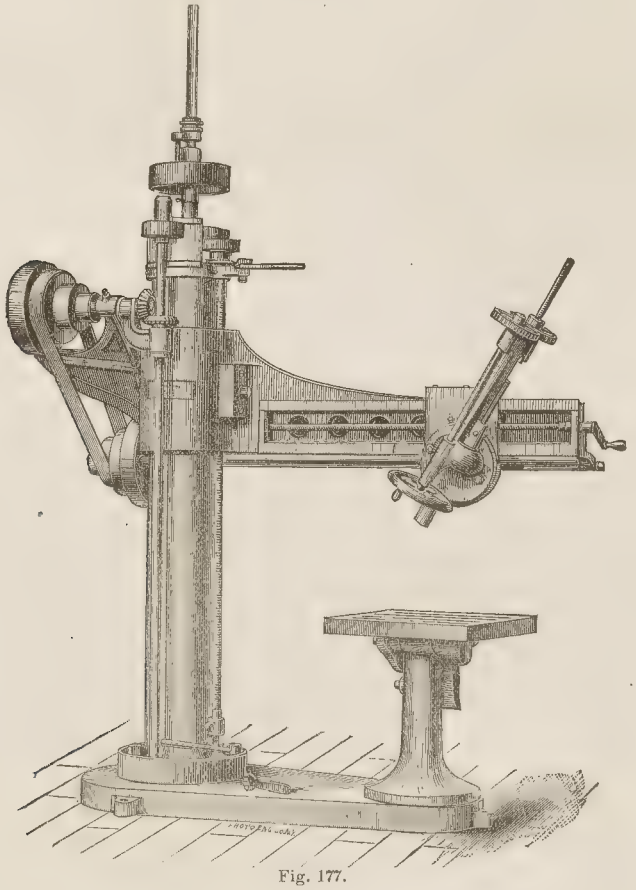


Fig. 177.

raised and lowered by power. In all the tools with this feature the column is a finished shell which turns upon an internal post with a long bearing. The shell is clamped in place by the bolts in the flange at its foot. It will be seen that by the two motions of this tool, a hole may be drilled in any direction and at any angle with the horizontal plane. The radius can bring the spindle into any vertical plane, and the swivel-plate permits the drill to be presented at any angle in that plane. Horizontal holes can be drilled in work of any length, the work lying on the floor or on trestles. Holes may be bored in erected locomotive-frames by using a long false socket.

Fig. 178 shows the spindle mechanism of Fig. 172 applied to a radial drill, and Fig. 179 shows a universal drill by the same builders. The radius slides on a faced slide, and the shell of the upright need not be finished all over. The raising and lowering is by power, the gears being engaged by the handled lever on the upright. The feed is by a screw, and may be made automatic with three changes, also as well as by hand.

Fig. 180 illustrates a belt-driven radial drill. The arm swings cranewise around a splined shaft through a little more than 180°. The guiding-slide is made very long for stiffness, so long as to need no clamping in place

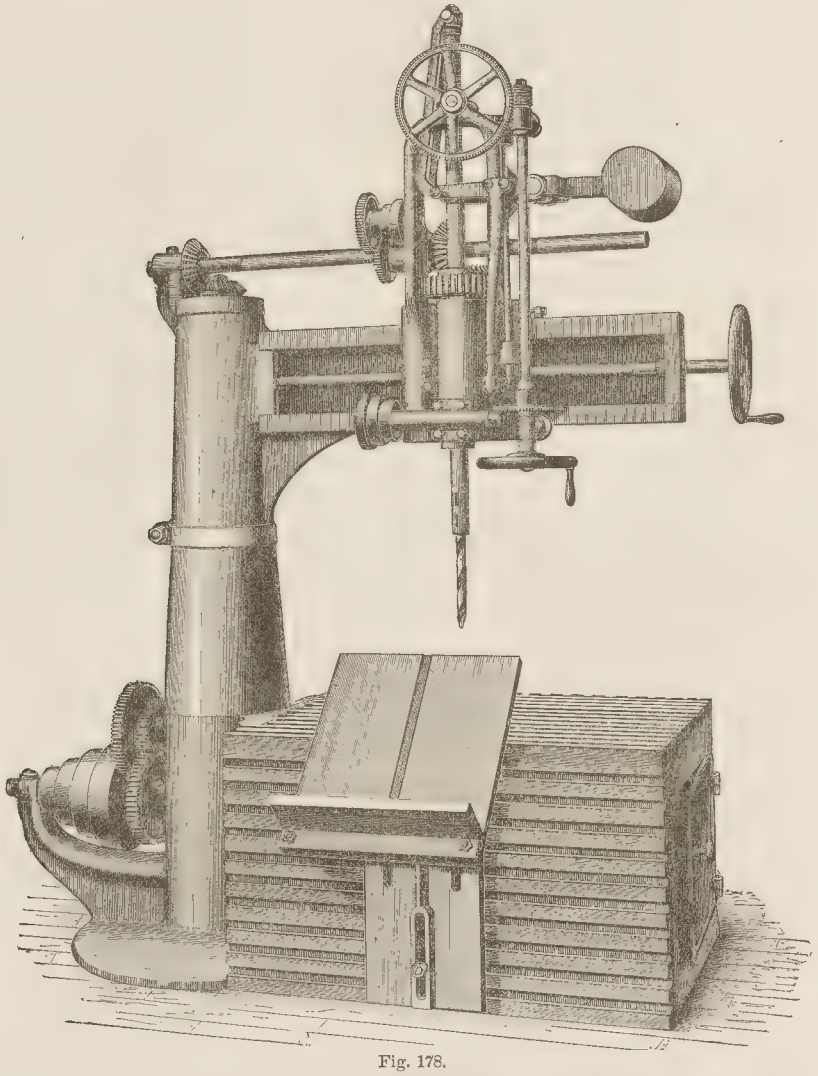


Fig. 178.

under a heavy cut. The arm is raised and lowered by power from the lower shaft. The feed is by a screw-gear, and the carriage traverses by a worm on a diagonal shaft taking into a rack. This cut and several of the others illustrate a form of table which has many advantages. Work may be secured to either top or side, and the interior may be used as a tool-closet.

Fig. 181 illustrated a similar adjustable double-faced table for a vertical radial drill. The spindle is carried at the lower end in a bearing on a slide, which is guided and receives the downward feed. The spindle itself, therefore, does not overhang its supports so far when fed out. The feed is by cone-pulleys from the spindle, with an axial spline device for altering or disengaging the power-feed. This has been utilized in an appliance for gauging

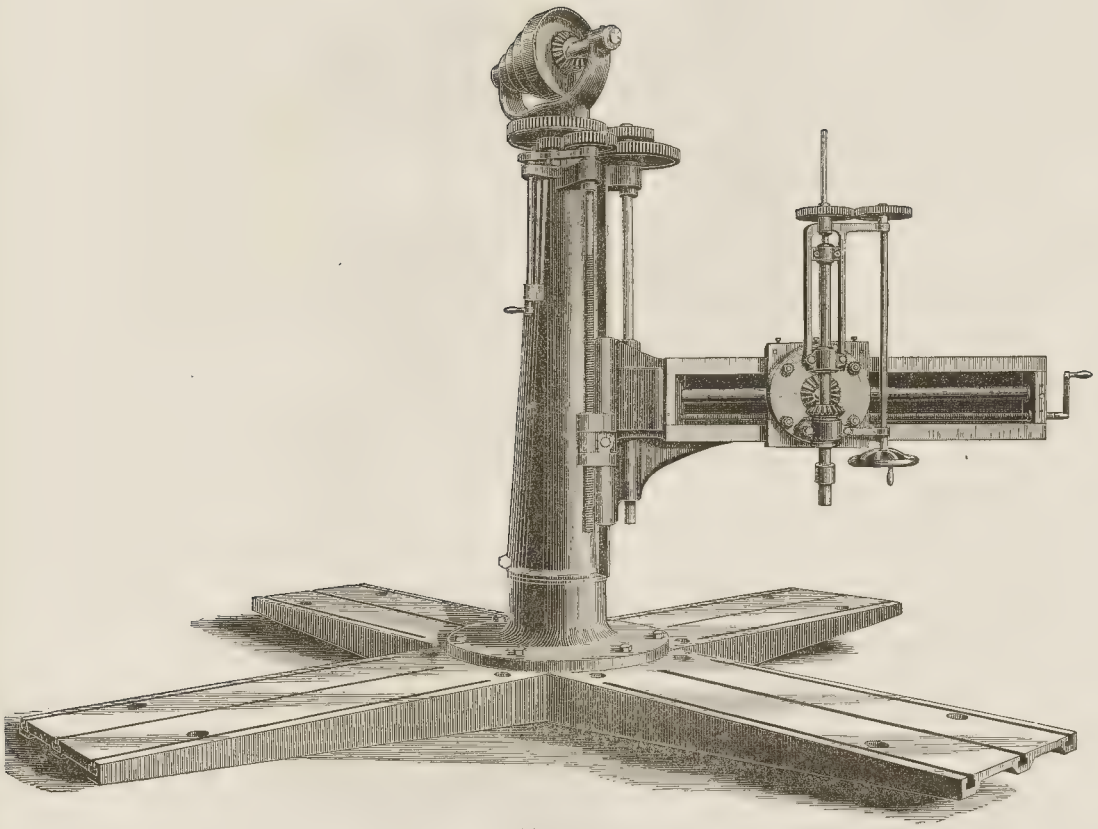


Fig. 179.

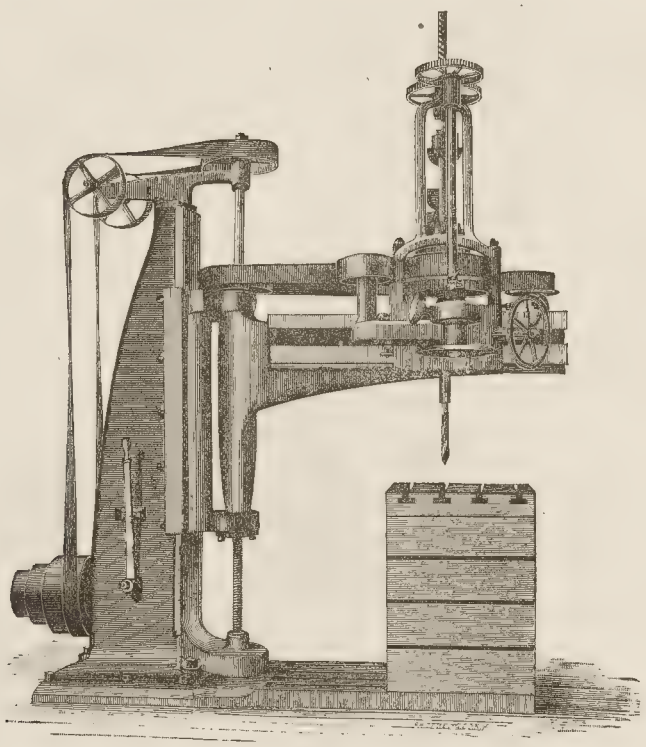


Fig. 180.

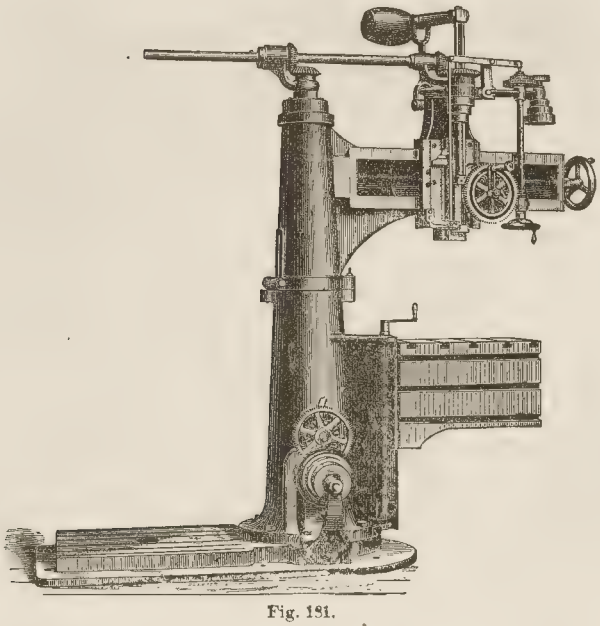


Fig. 181.

and tripping the feed for holes of uniform depth. The spline-rod is attached to a horizontal lever. A dog on the slide strikes a tripping-lever and disengages the feed-spline when the depth has been reached for which it was set. The hand-feed is engaged with the power worm-wheel by an annular friction-clutch.

Fig. 182 illustrates an improved universal radial drill, where all the motions are by power. The crane may revolve around the stump and rise and fall, and the feeds are by power. The jib may also turn around its own axis for oblique work, and the spindle may swivel to any angle. The engagement of the power motions is by hollow shafts and splines.

Belonging to the class of radial drills is the portable drill illustrated by Fig. 183. A short hollow post carries the column of the drill, which can thereby swivel to any radius by worm-wheel and tangent-screw. A long slide feeds the point of the drill in and out on the radius. The spindle-frame is held in a spherical clamp on a ball surface, by which the spindle can be set to drill at any angle up to 30° in any plane. A second sleeve,

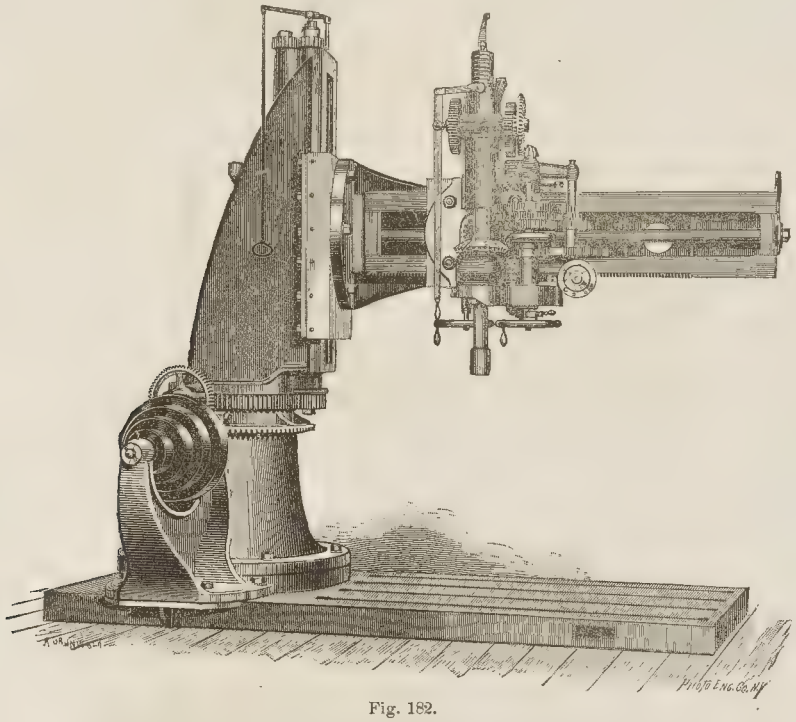


Fig. 182.

on the hollow post, will take the short column horizontally and give the same latitude of motions from horizontal plane. Power is transmitted to a cone of grooved pulleys by a round rope of Italian hemp, which passes over a guide-pulley at the counter-shaft and under another which is free and weighted to maintain the tension on the rope. The overhead guide-pulley is swiveled so that its periphery is always in the plane through the center of the driver in whatever direction the drill may be or at whatever angle. The entire adjustability of the drill in any position over a large area to drill at nearly any angle peculiarly fits this tool for erecting large work. The drill can more easily be brought to the work than the work can be presented to the drill. Of a very similar type of construction are the drills and boring-machines intended for the erecting shop, which are driven from counter-shafts upon the walls of the shop through rods with universal joints. A universal joint at the counter-shaft and another at the tool are connected together by telescopic shafts made of gas-pipe, with collars and set-screws. The two joints neutralize each other's irregularity. Even better than this is the similar use of flexible shafting. Coils of wire wound alternately into spirals, right-handed and left-handed, will transmit the power from a counter-shaft at any angle, and the necessity for supporting the shaft is entirely avoided. This must be done with the telescopic jointed system.

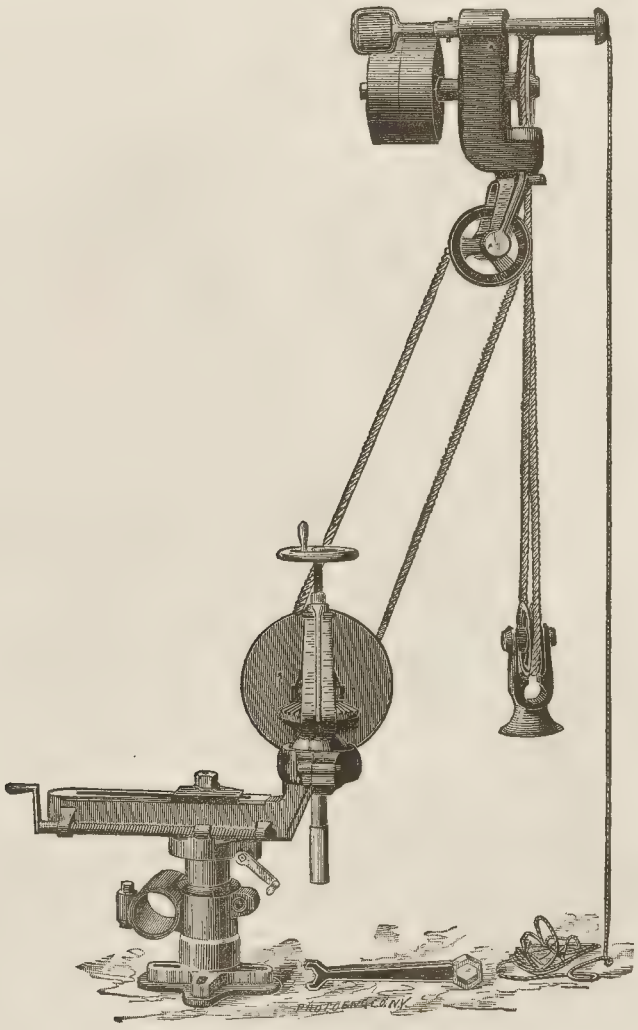


Fig. 183.

§ 23.

SPECIAL FORMS.

Fig. 184 illustrates a form of drill especially designed for drilling and boring the holes for the pins in the eyes of bridge-links. To insure accuracy in length it is wise to bore both holes at once, so that all may be alike. The heads slide upon a bed, and are arranged right and left. The links enter under one head and pass out through the other. Horizontal driving-belts pass from the drums over guide-pulleys to the driving-shaft. When the two heads are upon a wrought-iron screw for adjustment in length of the links, any changes of temperature will affect the link and screw equally, and the heads will slide on the cast iron to keep the lengths of all links the same. In other forms of this tool the spindles are carried on a cross-rail, receiving separate motion and feed from splined shafts geared to cone-pulleys. A primary advantage of this double system is that, by holding the work between centers, two holes may be drilled exactly parallel to each other and perpendicular to the axis of the work; or by putting bushings in the table, such a machine may be used for parallel boring, as in finishing the brasses of connecting-rods when keyed up in the stub.

Fig. 185 shows a machine for drilling the holes for crank-pins in the driving-wheels of locomotive engines. These holes need to be on radii at exactly 90° on the two sides. While the wheels are held by shoes upon their

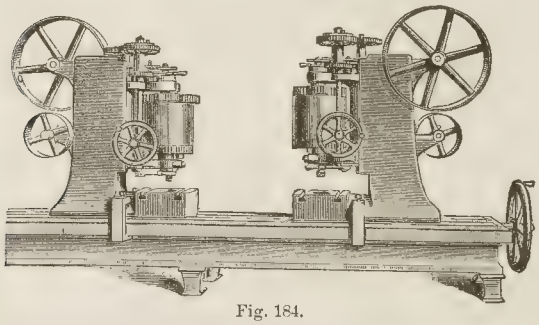


Fig. 184.

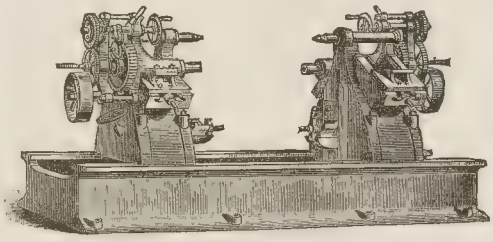


Fig. 185.

tread, and so adjusted as to bring the axle in line with the centers of the machine, the two drilling-spindles move on ways which are in planes at right angles to each other, and can be set for any radius of crank from 5 to 13 inches. The feed of the spindle is automatic, and variable within wide limits.

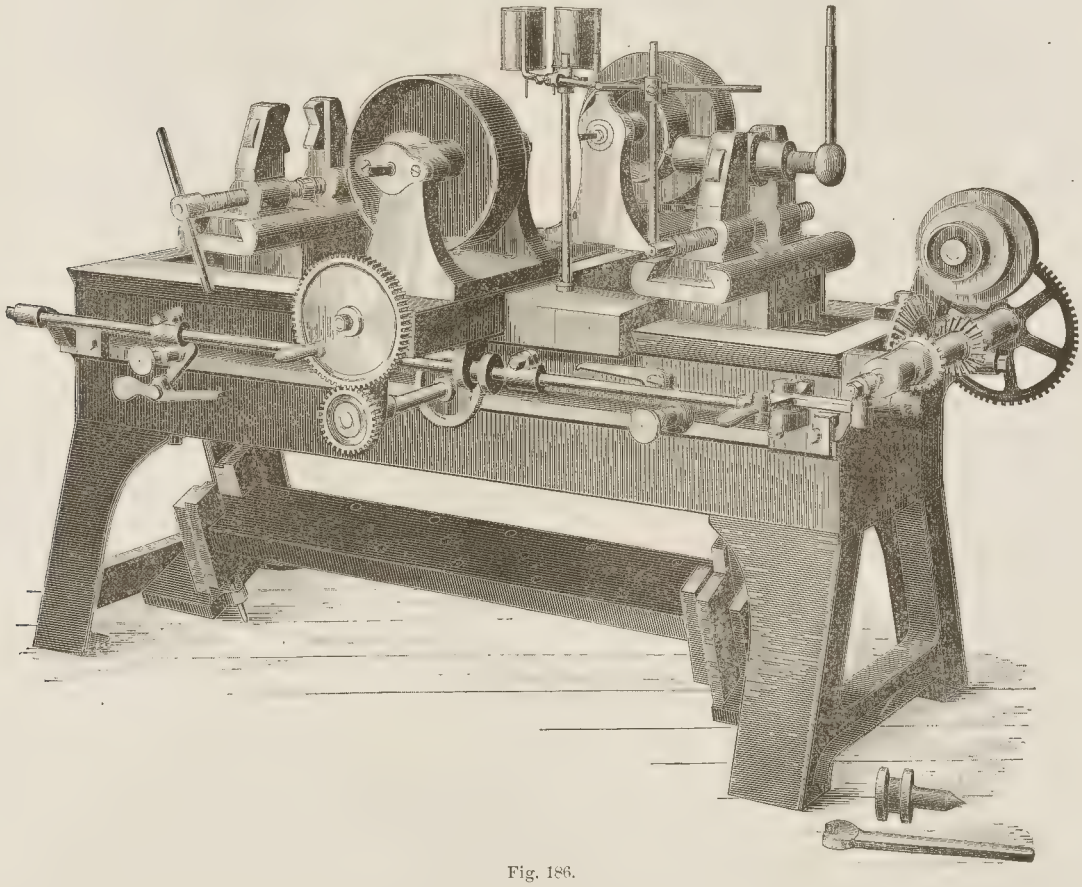


Fig. 186.

Fig. 186 shows a machine for drilling and mortising the seats for keys and cotters. Each drill has a longitudinal traverse of 36 inches and a transverse adjustment and feed of 10 inches. The feed is self-operating in all directions, self-reversing by the clutch and bevel-gears on the shaft at the right head, and the depth of the slot may be limited by a stop. The jaws are self-centering by right-and-left screw, and have capacity for a 7-inch shaft.

Fig. 187 shows a machine specially adapted for drilling the holes for the set-screws of pulleys without piercing the face. The drill is driven by a train of gears incased in the projecting arm, and the pulley is held upon the adjustable mandrel below. The machine has a capacity for pulleys from 56 inches in diameter down to 12 inches, and can also be used to tap the holes for the screws. The different speeds for drilling and tapping are obtained by the two belt-pulleys, and the motion of the tap is reversed by the clutch-lever in the head.

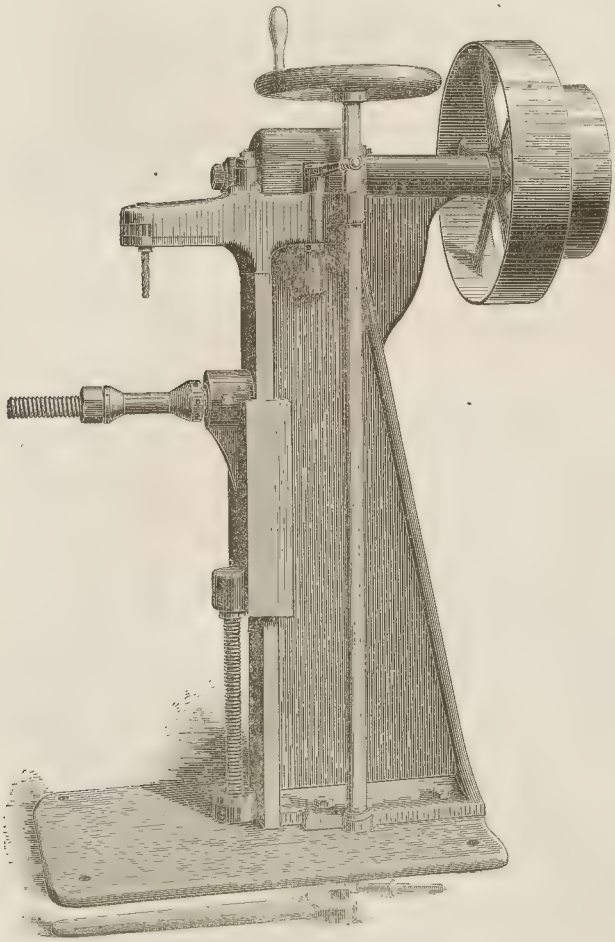


Fig. 187.

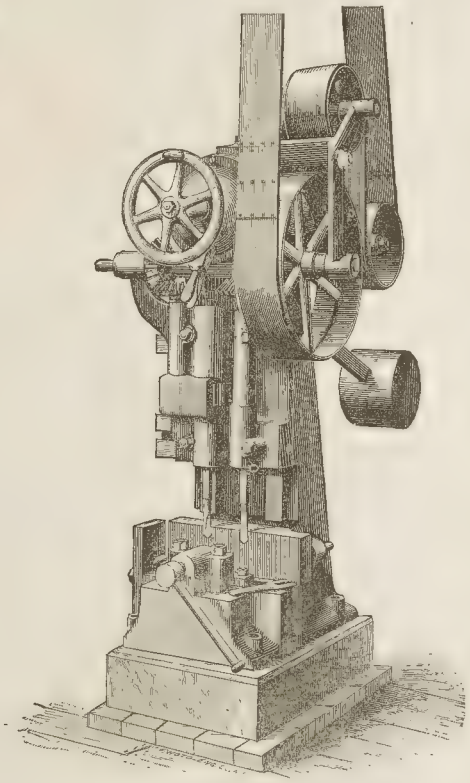


Fig. 188.

Fig. 188 shows a drill for the ends of steel rails, that the bolts for the fish-plates may pass through the web. The drills are fed down by a power-feed, positive and unvariable, the return being rapid by hand. The slide is counter-weighted, and the slack of belts is taken up by an idle-shaft linked to the driving-shaft. The rail is clamped in a vise upon the bed of the tool. These tools attain a rapid cut by high speed and fine feed. They are usually used in pairs, one at each end of the rail.

For drilling a number of holes at exact distances apart great economy of time results from the use of multiple drills. Fig. 189 shows a gang of four. The spindles are driven from a splined shaft, and can be adjusted to any distance apart greater than 7½ inches. The spindles are self-feeding and counter-weighted, and may be readily changed in relative height to suit drills of unequal lengths. The saddle which carries the drills is adjustable by rack and pinion on a cross-slide, which is long enough for sheets of 8 feet in width. The table is stationary, and the spindles are fed down by double worm-gear.

In the machine of Fig. 190 the spindles are six in number, and have no vertical feed. The machine is designed for truck-frames, and the spindles are made extensible by socket-arbors secured into the sleeve of the spindle by set-screws. The table is fed against the drills by a pair of cams driven by the worm-wheel at the right, so that the

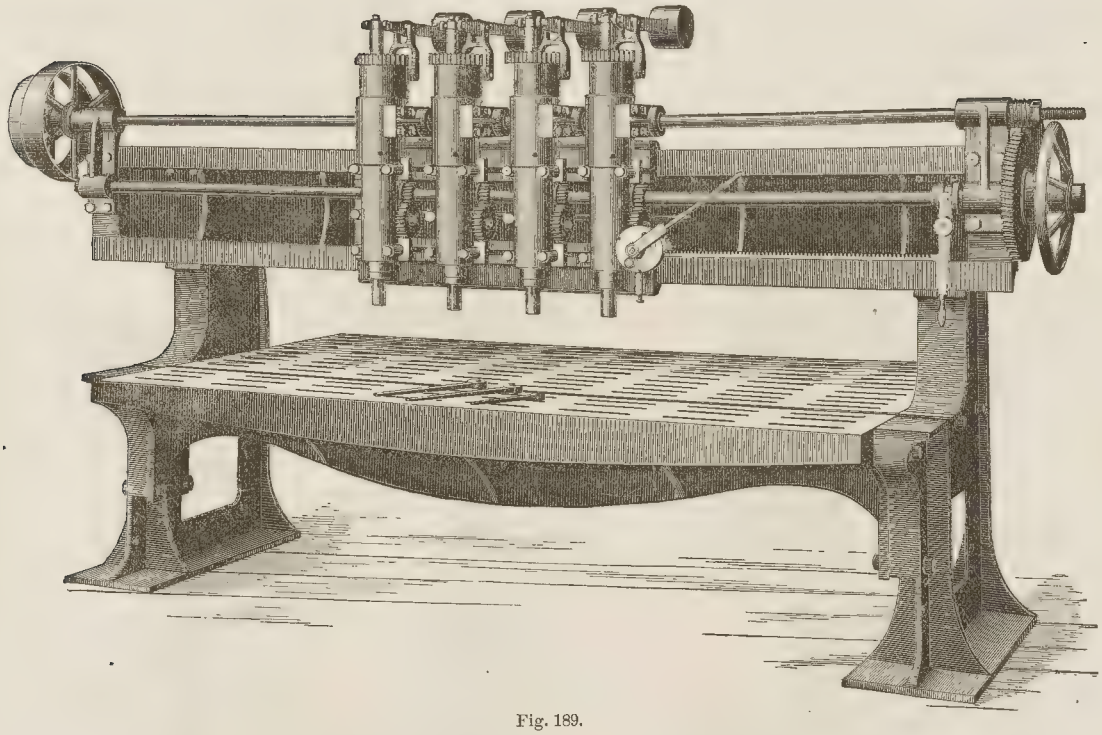


Fig. 189.

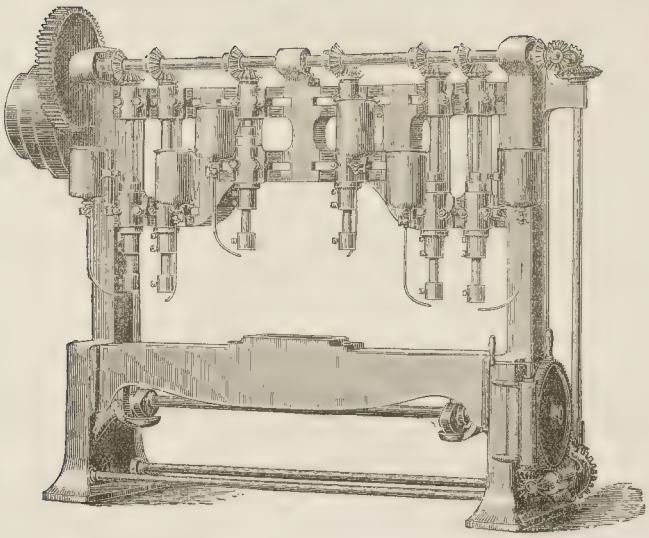


Fig. 190.

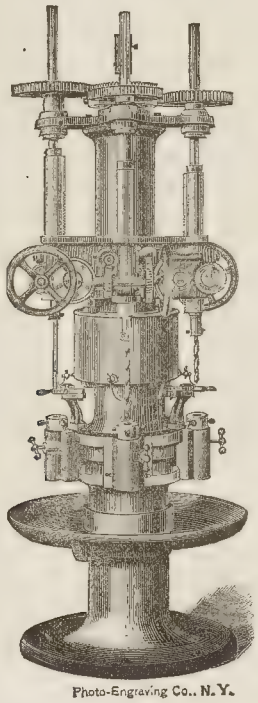


Photo-Engraving Co., N. Y.

Fig. 191.

feed and return motions are automatic. Sometimes the spindles are driven by a many-threaded screw of steep pitch, meshing into a helical gear on the spindle. This permits the spindles to be brought very close together. On account of friction, this helical system only works well against small resistances.

For a different class of work, where the holes are to be drilled deep in small work, the type of gang-drill shown in Fig. 191 is approved. It will carry a starting-drill, a through-drill, an enlarging-drill, and a reamer, or four pieces of work may have the same operation performed on them at once. The feed is automatic, and one operator can attend to several machines.

Figs. 192 and 193 show the belted gang-drill in two forms. The pulleys on the spindles may be of different

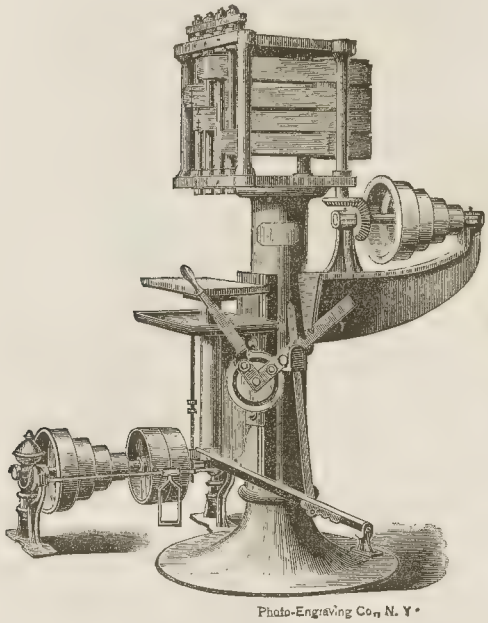
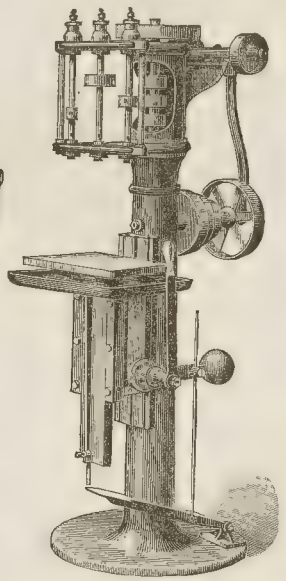
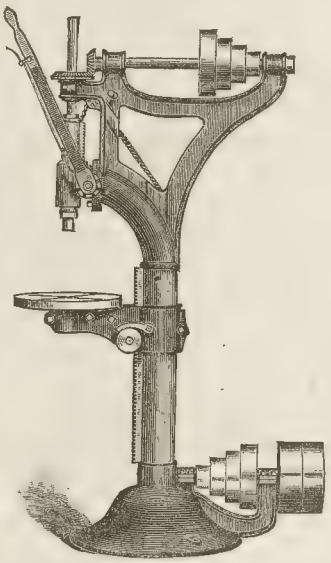


Fig. 192.


Fig. 193.


Fig. 194.

diameters if for different duties. The work is lifted against the drill by treadle or by hand-lever. The wear of the spindles is compensated for by take-up devices in the boxes, and the trouble caused by expansion of the spindles is avoided. The belts are made as long as possible.

Fig. 194 shows a type of drill approved for light work at high speeds. It makes a cheap design for a large class of manufactured articles.

Fig. 195 shows a tool for similar work arranged to have the work lift against the drill, which is belt-driven, and there is a stop device by nuts on a screw to gauge uniform depths.

Figs. 196 *a* and 196 *b* show a tool which has been approved in railroad and boiler shops on account of its limitless swing. The tool is called a suspension-drill, and is hung by the ring from the ceiling. Sometimes it is arranged so that the ring is on a carriage, which may traverse in two directions at right angles, making the adjustment of the drill-point more easy to the marks of the punch.

Fig. 197 shows a combination tool, drill, and slotter, which has found its use in certain shops. The slotter is disengaged by adjusting the wrist-pin into the center of motion and clamping the slide. The drill is fed by a screw from a worm on the spindle. It is disengaged by lifting the horizontal bevel-wheel out of gear by a milled head in the bracket.

Fig. 198 shows a special machine for drilling and countersinking centers for lathe work. The work is held by a scroll-chuck whose center coincides with that of the drill. The latter is fed forward by the ball-handle. Fig. 199 shows a similar tool, arranged vertically.

In all the tools which belong to this class of drills the workmanship in standard practice is of the best. The spindles are of hammered steel, the gears are cut, the important guiding surfaces are scraped to true planes. In the lower end of the spindle is made a taper socket, in which may be fitted a boring-bar or a secondary socket for drills. The sockets are most of them made with the Morse taper of $\frac{5}{8}$ of an inch to the foot. This is apparently displacing the so-called American taper of $\frac{9}{16}$ of an inch to the foot. At the top of the socket a slot is cut through the spindle, in order that a taper flat key driven through the slot may force out the drill without marring either

spindle or drill, and the end of the drill taper is so milled as to prevent the drill from turning in the socket, and yet it is certain to "center" as the two conical surfaces come together. The old collet and set-screw is rapidly disappearing.

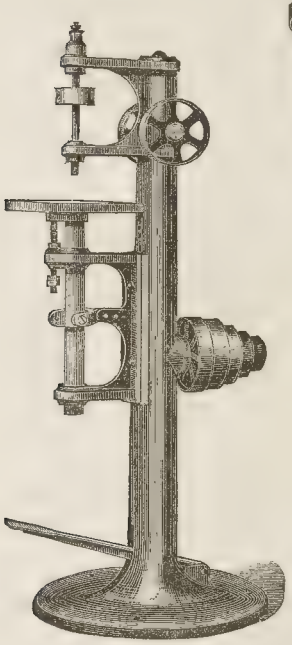


Fig. 195.

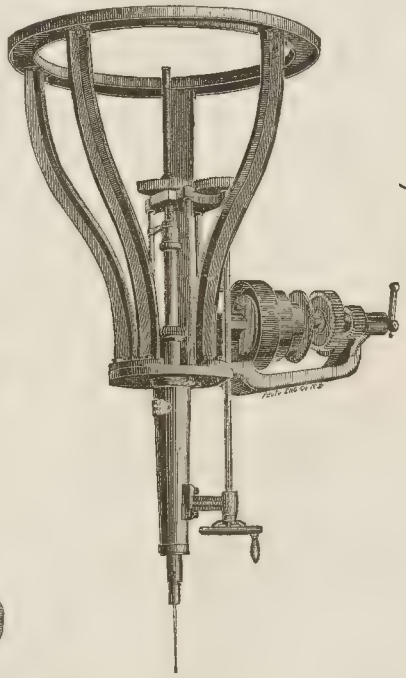


Fig. 196 *a*.

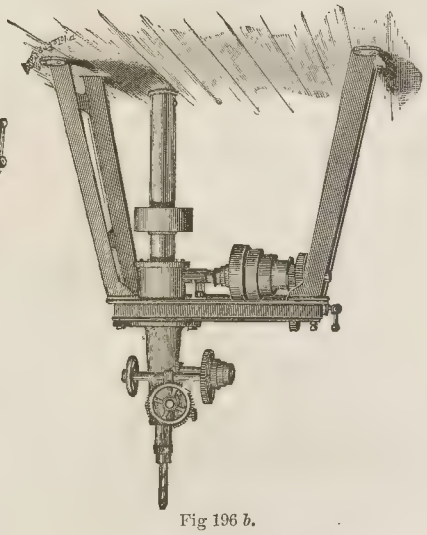


Fig 196 *b*.

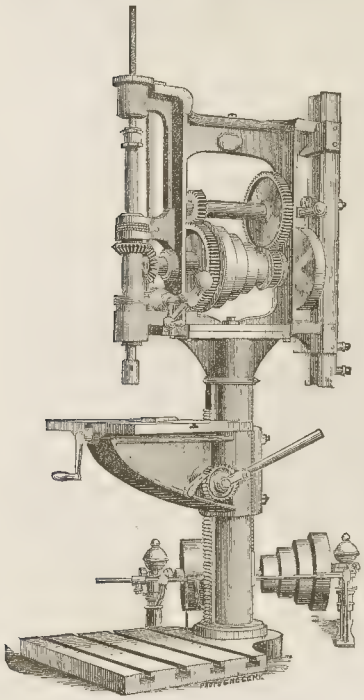


Fig. 197.

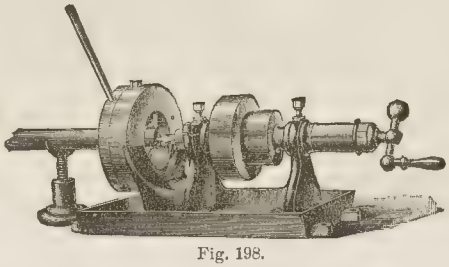


Fig. 198.

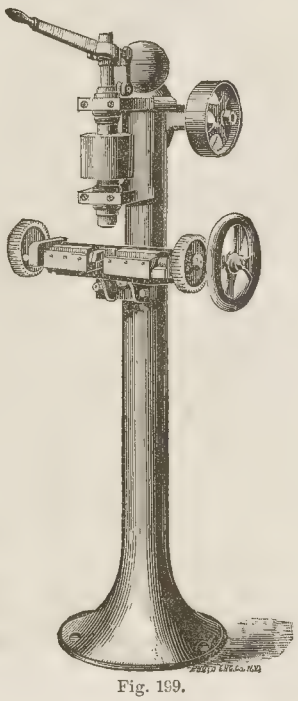


Fig. 199.

§ 24.

BOLT-CUTTERS.

These tools for producing the screws on bolts might come perhaps under the head of the lathes. They have become, however, of so much importance as to be separate machines, and to form a class by themselves. They belong to two classes. The first includes those in which the work is held stationary and the dies revolve. The second class includes those in which the work revolves, while the dies are held stationary. Advanced practice rather favors the first class. The bolt-cutters may be again subdivided into the fixed die-machines which must be reversed to release the work, and the movable die-machines wherein the bolt is released by the opening of the dies, so that the machine need not be stopped. The latter system is preferred because the integrity of the thread is not endangered by running the die backward over the thread. Any chip from the cut getting into the relief of the die may tear away or mar several threads. The movable die system is also more rapid.

There are differences with respect to the number of chasers, and the position of the cutting-points upon the

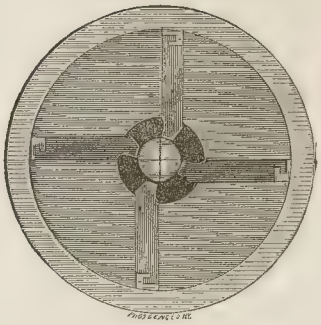


Fig. 200.

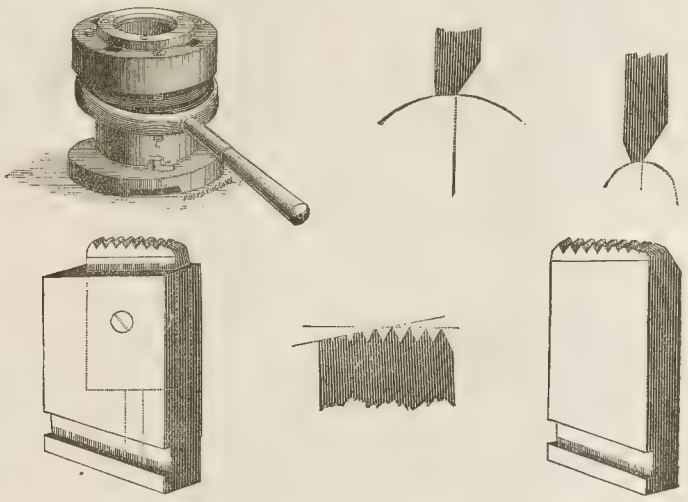


Fig. 201.

bolt. Prevalent practice prefers four cutters, although three are approved in some quarters. Against the three jaws it is urged that the rod is never cylindrical, and that when the long diameter is on any one cutter, the other two are resisting near the short diameter. This permits the stock to recede from the one cutter, and the thread will be uneven and the nuts will bind.

With respect to the position of the cutting-edge, the analogy of lathe practice has induced the system of Fig. 200. The cutting takes place at the ends of what corresponds to the horizontal diameter of a cylinder in the lathe. It is claimed, however, that when the cutter "leads" or cuts above the center the thread will be smoother than in the other case. On account of the play for adjustment of the jaws, a jaw nominally on the center line will often be really making a scraping cut below it. When this scraping occurs the edges tear the stock, instead of making a clean cut. Several good authorities, however, put the die on the center line, and nearly all favor the exact center for solid heads on account of lessened friction. When the dies are on the center line, the cutting or "hobbing" of the dies

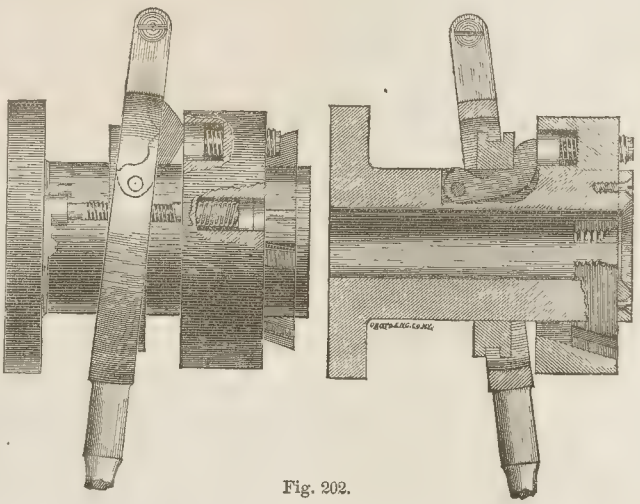


Fig. 202.

is done by a master-tap larger in diameter than the size called for, to secure the necessary relief at the heels of the cutters. When the cutters lead the center a smaller tap is necessary for the same purpose. The adjustable heads make this variation in size very easy while being cut.

Fig. 201 shows the hand-relief given to the tap, to give only the required amount of cutting-face, and also the relief for the entrance of the blank. The length of the cutting-face will vary with the speed and the severity of the work of the cutters. The same figure shows a case-die, in which the die proper is held in a holder. After being properly shaped the cutters are hardened, the threads being coated with soap to prevent scaling. The temper is drawn to a medium straw color, and the quenching is done in linseed oil or in water. The oil is thought to toughen the steel. While domestic steel has given results fully equal to those of imported grades, the tool-makers complain of the lack of uniformity and reliability which they encounter in its use. On this account only the imported product is preferred to the American at this date.

Fig. 202 illustrates one of the types of adjustable head in very general use. The dies fit in rectangular slots, by which radial motion alone is permitted. The dies have an oblique gain or mortise on one side, which fits a corresponding tenon in the external chucking-ring. When, therefore, the ring is moved forward the dies will close inward. When it is moved backward, the dies will open and release the bolt. The position of the heavy ring, and therefore the size of the thread cut, is determined by a small latch, which is held and released by the grooved ring pinned to the lever. This latch abuts against a screw in the heavy tenon-ring, which may be set at pleasure. The head is retracted by the long screws which pass through the tenon and grooved ring, thus uniting them together. The end of the long screw abuts against a stop, to prevent the rings from coming back too far. When this stop is swung out of the way, the dies are released, and can be exchanged for others. The shifting of the lever can be made automatic, so that the dies may be released when any desired depth of thread is reached. The entire machine is shown by Fig. 203.

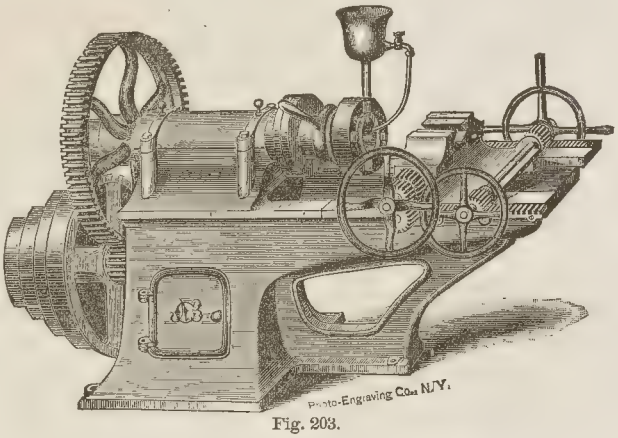


Fig. 203.

Fig. 204 shows a similar device for setting the jaws. The machine is entirely automatic. When

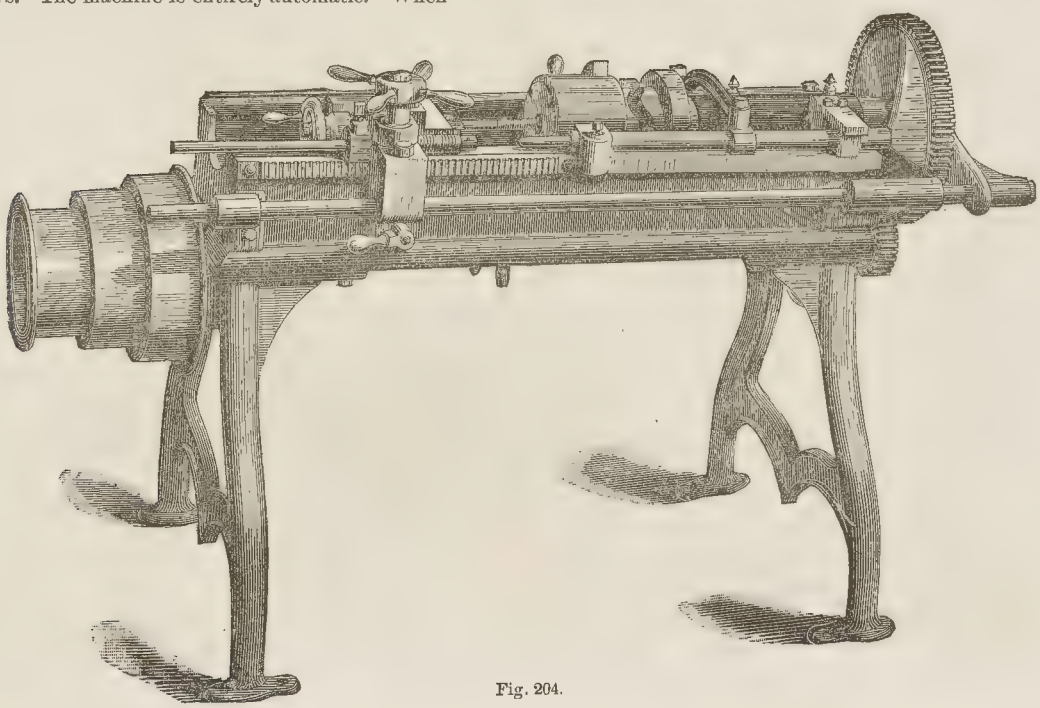


Fig. 204.

a latch is engaged with the ratchet-tooth on the head at the proper depth the outer ring is arrested and the flat groove on the inner sleeve retracts the keys on the jaws by virtue of its continued motion. At the same time the inclined plane on the large gear forces back the carriage and the finished bolt. The continued motion of the inner sleeve resets the jaws and locks them by the straight part of the groove. These tools are also arranged to hold the bolt between centers while being cut, in order to secure the same diameter of all threaded stock.

Fig. 205 shows another type of automatic machine, and Figs. 206 and 207 show its details. Three dies are held in radial slots in the head which is driven by the outer and larger gear-wheel M. This wheel is fitted loose on the hollow spindle B, and is secured to the latter by two bolts. These pass through the plate of the wheel and through circular slots in two arms, D and D′, which form part of the main spindle B. The position of M upon the spindle B is thus adjustable, and may be noted by a pointer, *d*, on the arm D, which moves over a scale upon M. The inner and smaller wheel, M′, is keyed to an outer sleeve, B′, which fits over B and carries a set of three cam-plates, *b*, upon the flange of the head. These cams are milled out on their inner edges to a spiral curve. These curved edges resist the radial motion outward of the dies when cutting, and it will be seen that the opening between the cutters will be determined by the relative position of the sleeve B′ and the driving-spindle B. If B′ were to revolve faster than B, the cutters would abut against a surface of *b*, which would get gradually farther from the center, and the dies would open. The wheel M′ is driven from the wheel M when the tool is cutting by projections E E upon their hubs. When these projections are in driving contact, any desired relation between the dies in B and the cam-plates upon B′ may be secured by bolts in the slotted arms D and the index pointer *d*. Any adjustment for wear, or any varied sizing of thread, large or small, may thus be effected. The large wheel M is driven from a pinion, F, keyed on the cone-pulley shaft. The wheel M′ meshes into a little larger pinion, F′, loose on the same shaft. A spiral spring, I, abutting against an adjustable collar, K, presses F′ against F, the adhesion being increased by a leather disk between them. When the spring is permitted to act, F will drive F′ by friction until the projections E upon the hubs come in contact, when the friction-disk will slip and B and B′ will move together. But F′ may be moved by the hand-lever H and the counter-weight L so as to bring a male cone on it into a female cone which is fast in the leg of the machine; this arrests F, M′, and B′, while B still moves. Small spring cams, *c*, move out the dies in the head as they are relieved from the spiral of *b*, until the projections E on the hubs engage on the other side. The head then turns with the dies open until the lever H is latched back, when the spring I is permitted to act and the dies slowly close by the more rapid motion of M′ and B′. A rod in the axis of the cutter-head may be set to release the latch of H when any desired length of thread has been cut. This compact method of causing different relative speeds in the two large gear-wheels and utilizing the differential motion for moving the dies renders this a very notable machine.

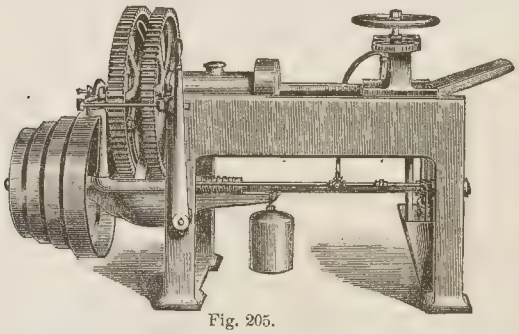


Fig. 205.

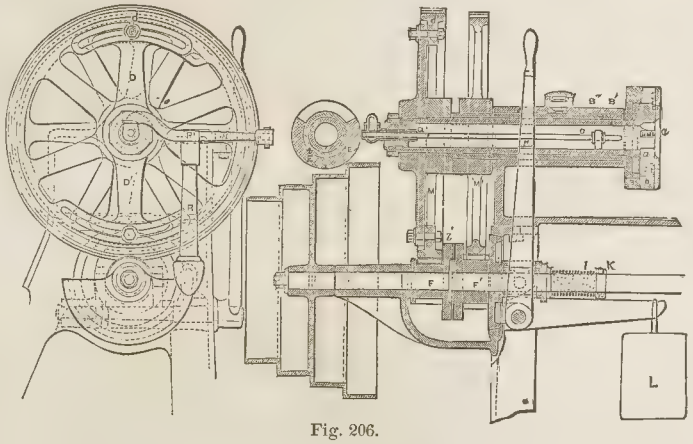


Fig. 206.





Fig. 207.

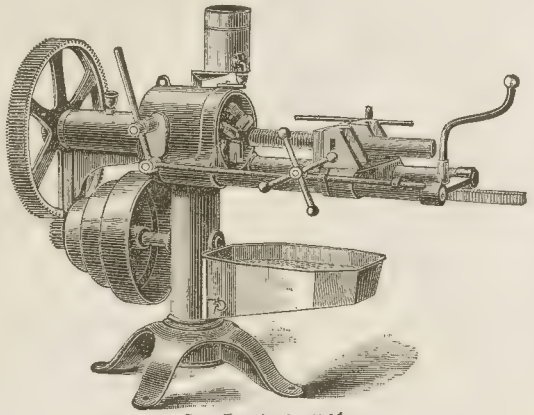


Photo-Engraving Co., N. Y.

Fig. 208.

The tool shown in Fig. 208 illustrates another arrangement. Each of the cutters is carried in a species of holder made of a steel casting. The die is held in the holder by two set-screws on the side and one on the end. The holder has a turned stud near one end whose axis is parallel to that of the bolt to be cut. This stud fits into the head so that by the rotation of the holder around the stud the cutter-jaws approach or recede from the center. The holders are forced and held to their cut by a pin with inclined end, which moves parallel to the axis of the head and bears upon the back of the holder. The motion away from the cut is effected by stiff springs. These holding-pins are attached to a sleeve, which is moved forward by a spiral spring, and is moved backward when a pin is

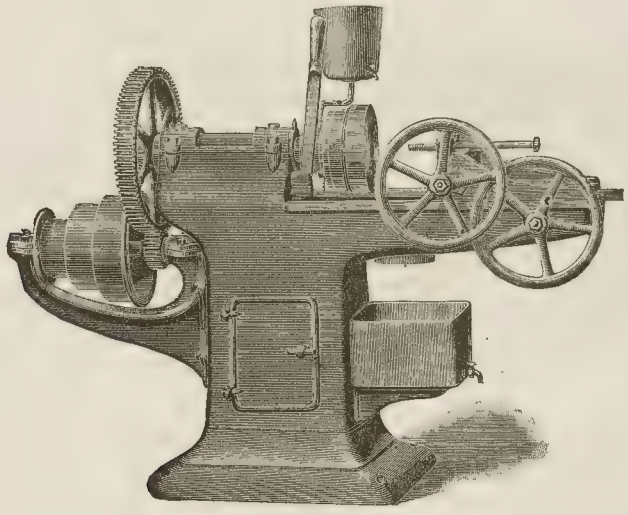


Fig. 209.

released by a latch and drops into an inclined groove in the sleeve. This latch is moved by the bolt being cut, so that any desired length of thread may be produced. The bolt-cutters of Figs. 209 and 210 show the standard New England form of this type of machine.

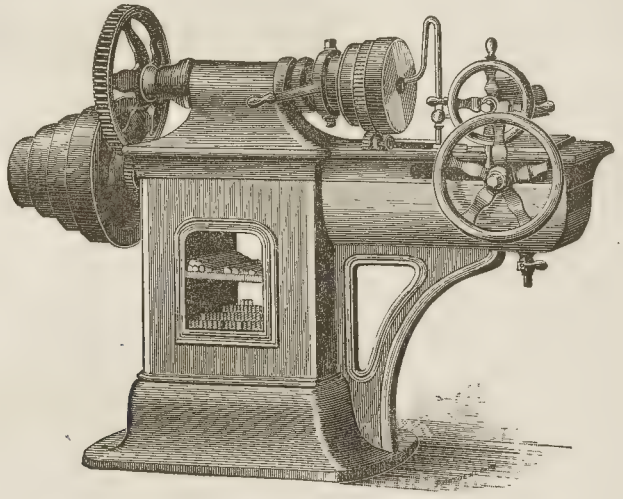


Fig. 210.

Fig. 211 shows one of the largest machines of this class ever made, designed to cut the threads on 6-inch rolled iron. It was first built for the heavy bolt and turn-buckle work in the pumping and hoisting plants in deep mining in the state of Nevada. The machine weighs 10 tons, the large gear is 5 feet in diameter, and the 6-inch tap alone weighs 200 pounds. The same builders make smaller machines, presenting the same advantages as the other designs.

All these machines are fitted with self-centering jaw vises for holding the stock (Fig. 215). In one type the vise is geared differentially, giving great power. Usually the jaws are worked by screws only, either right-and-left handed, or else geared together. They are fed forward to the jaws by a rack and pinion and hand-wheel, or else by a lever. The designs and motions of the vises are shown in the cuts.

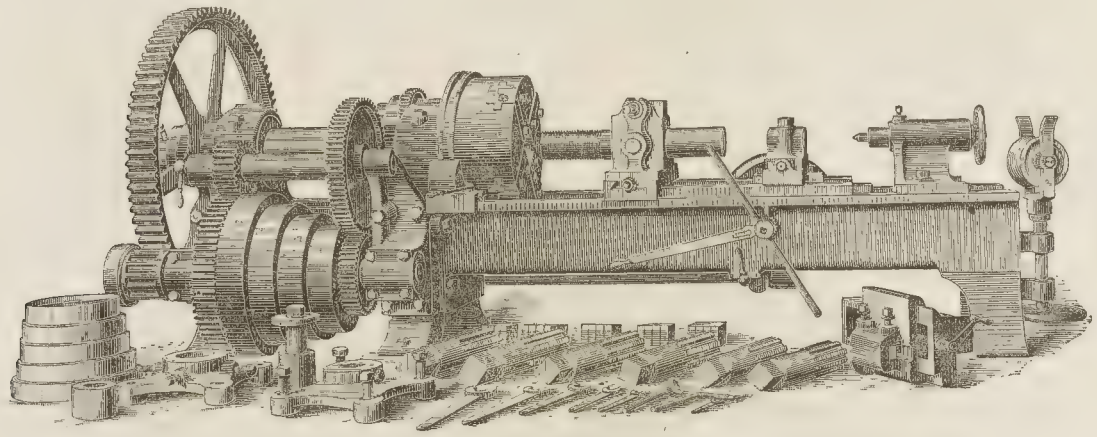


Fig. 211.

For bolt-cutters of the second class, where the bolt revolves and the die is stationary, a solid die is used. One of the types is shown by Fig. 212 *a* and *b*. The cutting-chasers are inserted in an iron collet, encircled by a wrought-



Fig. 212 *a*.

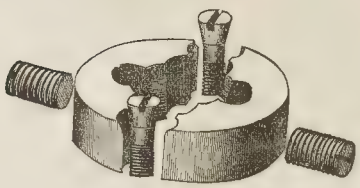


Fig. 212 *b*.

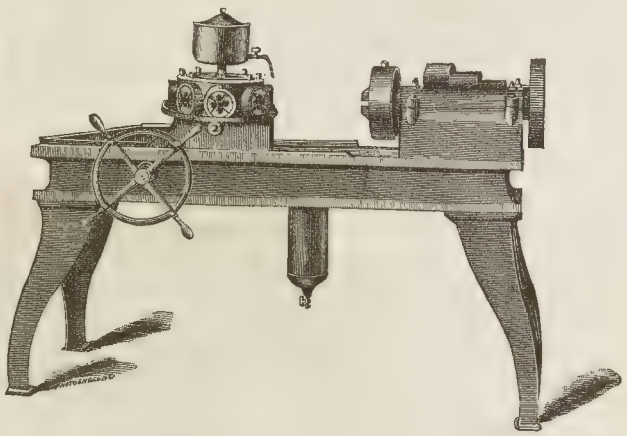


Fig. 213.

iron ring, beveled on the inside. The chasers are beveled to fit the ring, and the latter is secured to the central flange of the collet by adjusting- and distance-screws. An adjustment of $\frac{1}{32}$ of an inch or more may be made in the cutting size of each die. The collet is split, and the opening may be lessened by slacking off the conical screws.

Figs. 213 and 214 show the types of the entire machine. A number of dies are held in a turret-head, and are fed against the revolving bolt by the hand-wheel, pinion, and rack. In Fig. 214 a slide is fitted with sockets for various sizes of nuts. The taps will be held in the jaw of the head (Fig. 215).

A type of movable jaw-head for cutters of this class is shown by Fig. 216. The cutters fit into chuck-plates, which have spiral grooves in their back. The size of the thread will be determined by the position of the stop in the curved slot at top. The blank is released by the revolution of the holder by the hand-lever shown. For tapping-nuts any of the machines illustrated may be applied directly by the simplest inversion, or by replacing the cutting-jaws by a pair adapted for holding a tap.

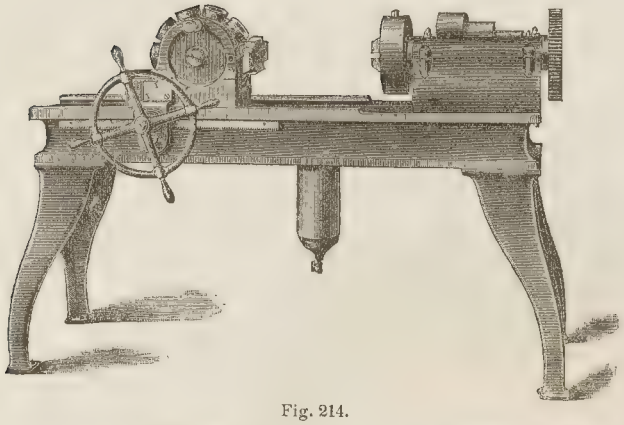


Fig. 214.

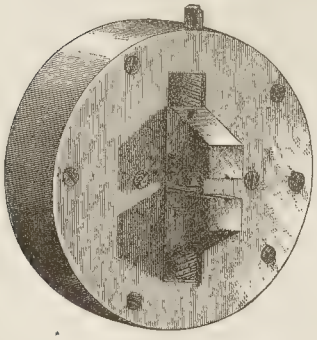


Fig. 215.

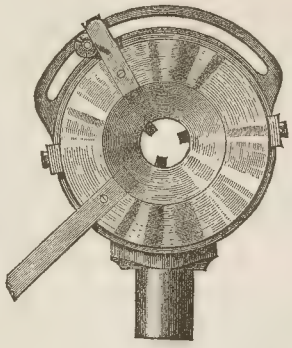


Fig. 216.

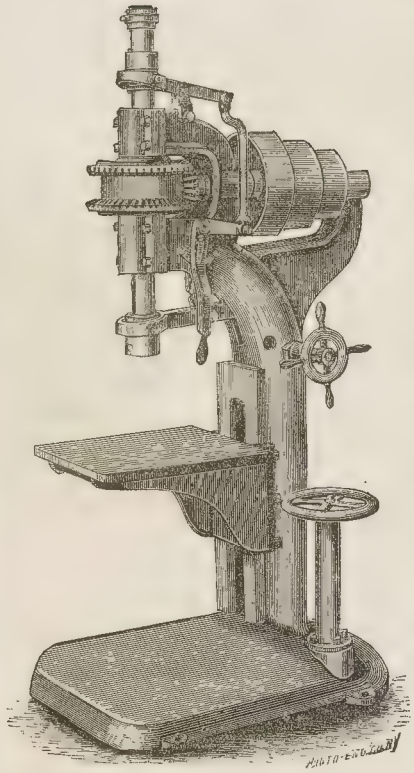


Fig. 218.

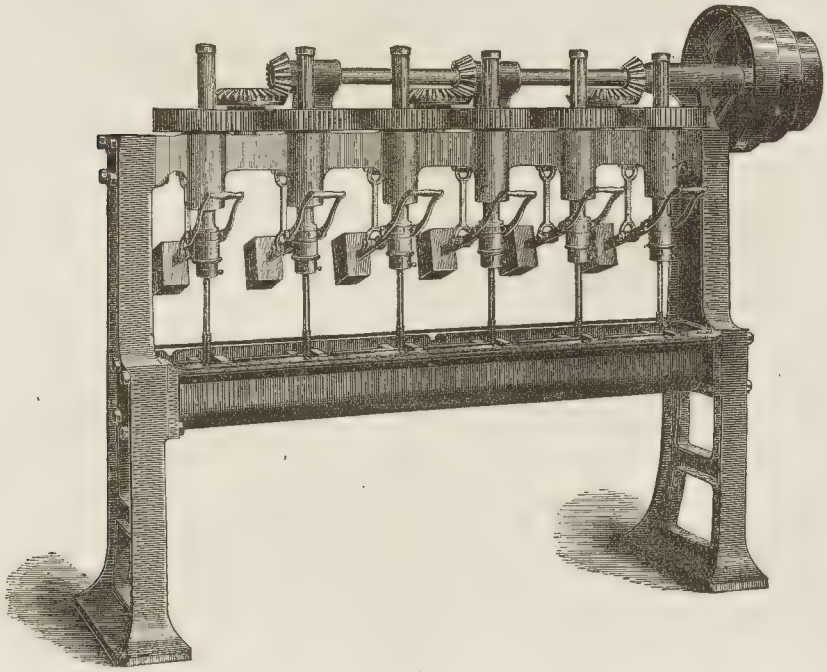


Fig. 217.

Fig. 217 illustrates a multiple vertical machine of six spindles. The spindles are counterpoised, and the nuts are immersed in oil while being tapped, and slide into their fit in the holders. The vertical tappers have the advantage of washing away the chips from the cutting-edges. On the other hand, in the tank-machines the tap may revolve in a film of oil on the surface of water. The water cools the tap, and the oil relieves the friction. The

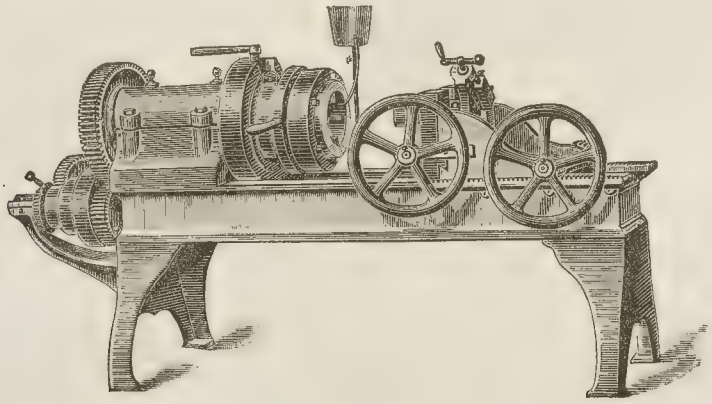


Fig. 219.

mineral oils do not answer for these purposes. Animal oils must be used, or a soda water, or an alkali mixture, made up of 10 pounds of carbonate of soda, 4 gallons of whale oil, 3 gallons of lard oil, and 40 gallons of water. These lubricant mixtures are either held in cans and delivered from a long spout at the cutting-point, or else are pumped on the work in excess to wash away the chips. The spent oil is strained into a reservoir and used over and over again, whence results a notable economy.

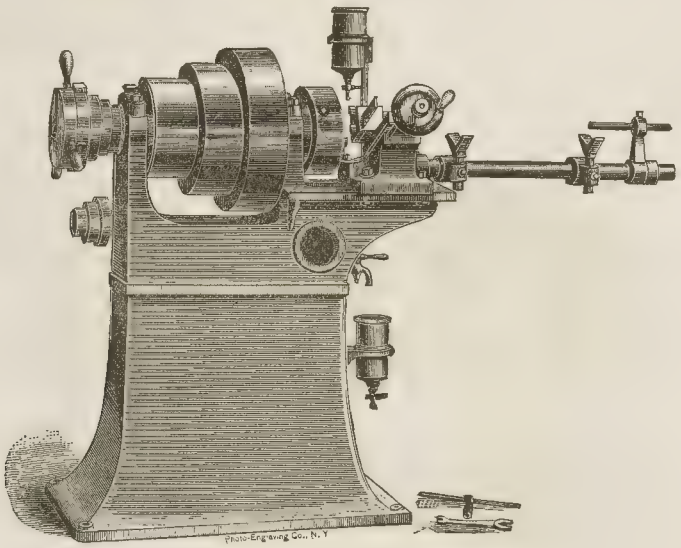


Fig. 220.

Fig. 218 illustrates a machine for tapping general work in cast iron, where the work will be run dry. The spindle is driven in one direction or in the other by a clutch between the horizontal bevel-wheels, which is operated by the lever. The spindle is fed down by hand, and the table is adjusted by screw and hand-wheel.

The machines for threading pipe differ in no essential respects from the bolt-cutters. The smaller sizes are usually worked with solid dies, the pipe being held in jaws in the head and passing through the hollow spindle. The larger sizes use adjustable dies in a revolving head (Fig. 219). Where the pipe is held stationary the required length may be cut by fed cutters in the head. Where the pipe revolves, the lengths must be cut either by a cutting-

off tool, on a rest, or else in a separate machine. This latter class of machine is known as a cutting-off lathe, and types are illustrated by Figs. 220 and 221. The spindle is hollow, with a jaw at one end and a bushing, or, better,

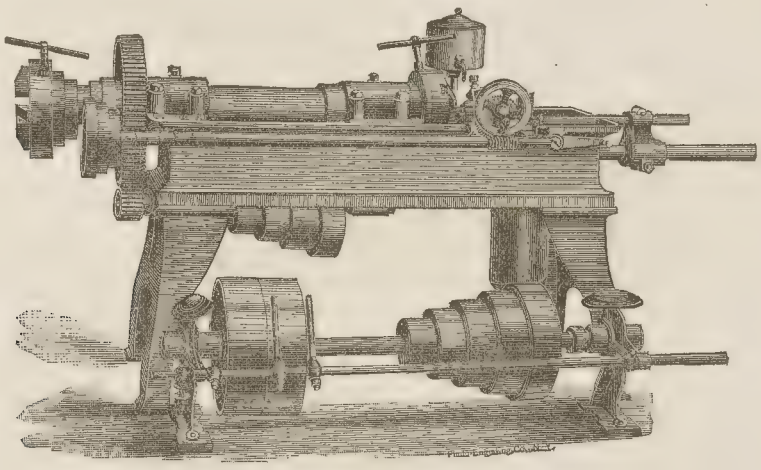


Fig. 221.

a self-centering chuck, at the other. The tool is fed obliquely downward by hand and by power, the required length being gauged by a stop. The tool may be forged of such a shape as to be efficient until it is ground so short as to become useless. Tools in holders are frequently used.

§ 25.

SCREW-MACHINES.

For making machine- or set-screws from the bar which has the shape for the head, a screw-machine is required. This may have several forms. For large work, a machine of the type of Figs. 222 and 223 would be used. The

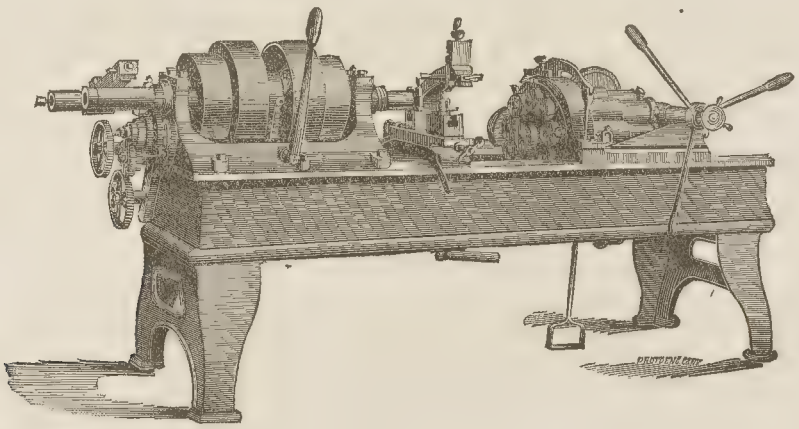


Fig. 222.

spindle is hollow and receives the rods. The tail-head carries a number of spindles, each of which is adapted for one operation on the screws. The tools are fed forward by rack and pinion by the levers, and the one in operation is held from motion by a pin on the treadle-lever. Larger screws will be chased by the slide-rest and hobs; smaller ones will be cut by dies in one of the spindles.

Fig. 224 shows a similar arrangement of tools. The linear motion is assured by the slotted disk on the tail-disk spindle, and an adjustable stop controls the lengths. Tools of this type may use tool-holders with detachable cutters for sizing, etc., thus avoiding the expense of hollow mills.

Fig. 225 shows the very usual application of the turret-head for this class of work, with a chasing-rest.

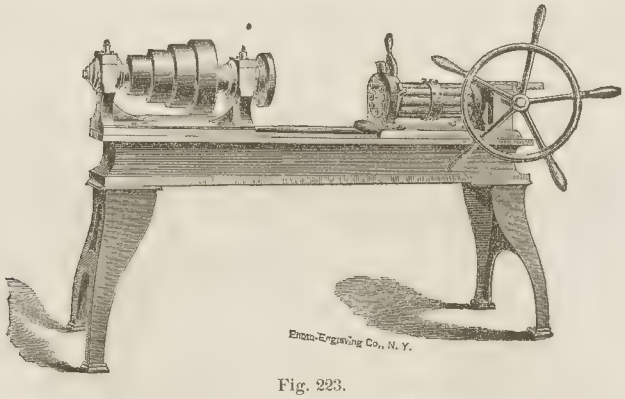


Fig. 223.

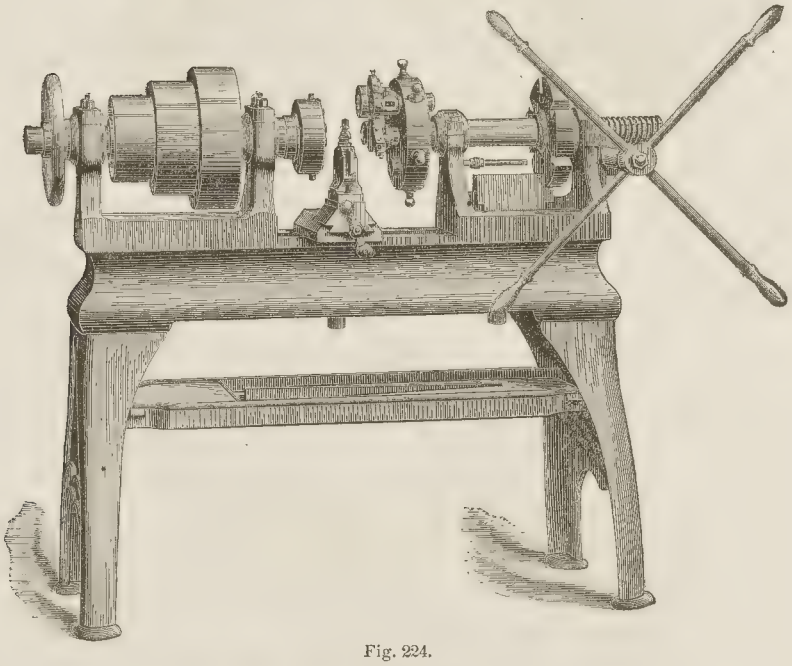


Fig. 224.

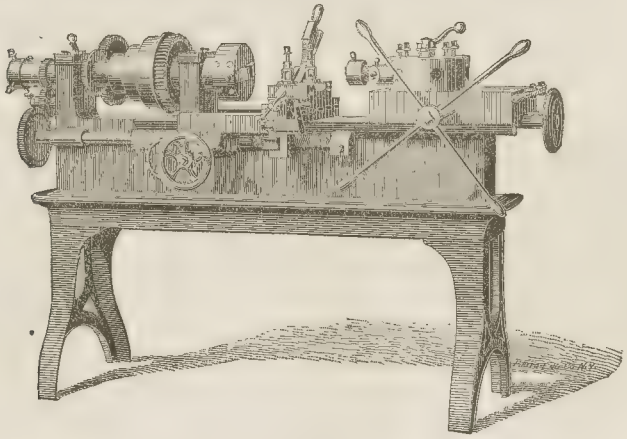


Fig. 225.

Fig. 226 illustrates the smaller machines without chasing-head the slide-rest being used for sizing and cutting off only.

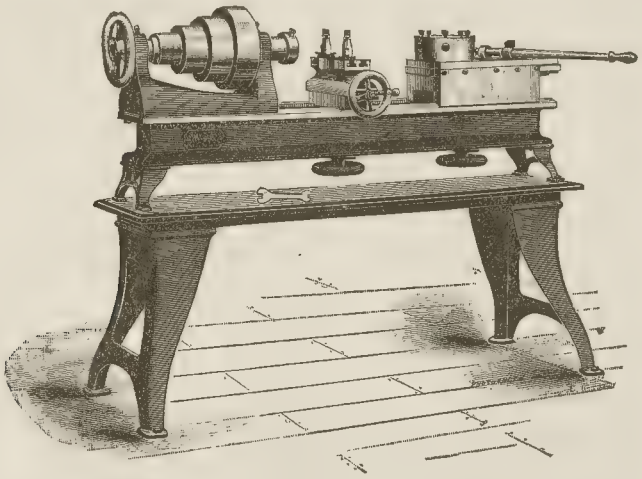


Fig. 226.

Fig. 227 shows the detail of this rest, giving the stop and gauge adjustment at the left, and Fig. 228 illustrates types of tools and holders. Machines of this class are capable of doing a great variety of work with very close

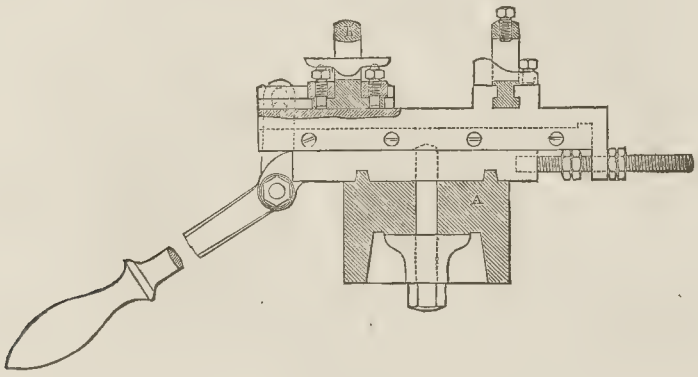


Fig. 227.

accuracy and at high speed. They are especially adapted for finer grades of work, and when so applied will operate to a margin of error within $\frac{2}{1000}$ of an inch.

Fig. 229 illustrates specimen products of such a machine.

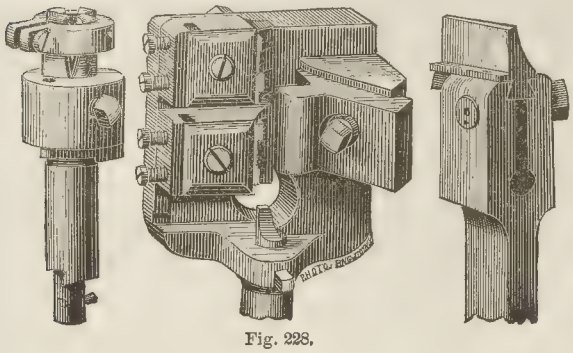


Fig. 228.

Fig. 230 illustrates a type of screw-machine, designed to give better support to the turret. The turret swings on two horizontal supported journals, instead of on one overhanging stud. The tendency to wear the turret loose upon its supports is thereby reduced. Several of its other excellencies are visible from the cut.

The smaller screw-machines are usually equipped to produce the sharp V-thread, which remains in very general use at distances from the centers of enterprise. The larger tools cut the flattened V-threads of the American standard unless specially ordered otherwise. Pipe-threads are uniform all over, and consist of a sharp thread cut with a taper of $\frac{3}{4}$ of an inch to the foot.

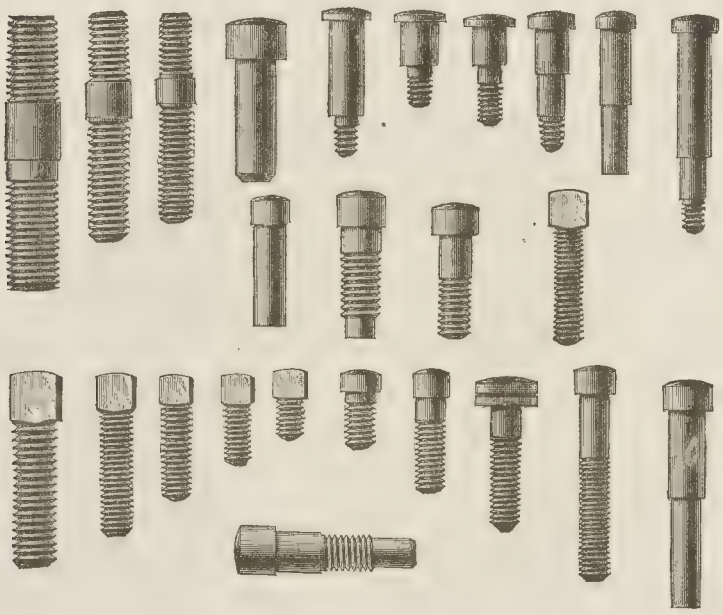


Fig. 229.

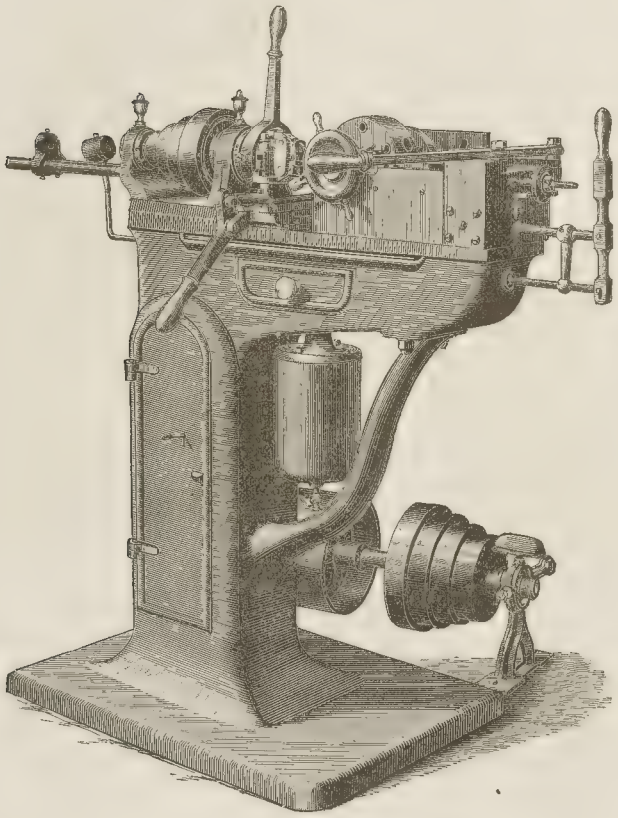


Fig. 230.

§ 26.

PARING-TOOLS WITH LINEAR MOTIONS—PLANERS.

The tools with rectilinear motions of work or of the cutter are especially adapted for producing plane or flat surfaces. The shaper and slotter are adapted for smaller work, or for work where the tool traverse need only be short, and they will readily work out curved profiles by cutting along their elements. But the planer is especially applicable for the production of large or long surfaces which must approach true planes.

The planer will consist of a table or platen moving backward and forward upon ways in a bed-casting. This table moves below a cross-head, which is borne upon two uprights, bolted to the bed-casting. The tool is secured to a slide upon this cross-head, and receives feed-motions in different directions. The gear for driving and feeding are the points in which there is the greatest divergence in the practice of to-day.

There are several reasons for making the table and the work move under the tool, which is stationary, except for its feed-motions. If the tool had to travel any distance, it would be very difficult to produce true horizontal planes. The overhang of the tool, varying at different points, would cause the chip to be always lighter when the slide was farthest out. Beside, the freedom of the slide for ease of motion would cause errors. By reversing this system the tool has its lost motion a constant, for the play of feed is the same at all points of the surface. Moreover, the weight of the table and work acts in the same direction as the strain of the cut, all being downward upon the ways of the bed. The play for motion is therefore resisted by the constant weight of the table and work, and there can be no yielding of the support for the work. If, therefore, the ways be true, and the upright and cross-head are stiff enough, true planes will be produced by this system. There is less gained by this form of tool when planing vertical surfaces. But its capacity for this class of work is small on the medium sizes, on account of the proper support of the tool. When these smaller machines are called on to do extensive vertical surfacing it is not unusual to invert their system and secure the work to a floor-plate, while the tool-holder is bolted to the bed,

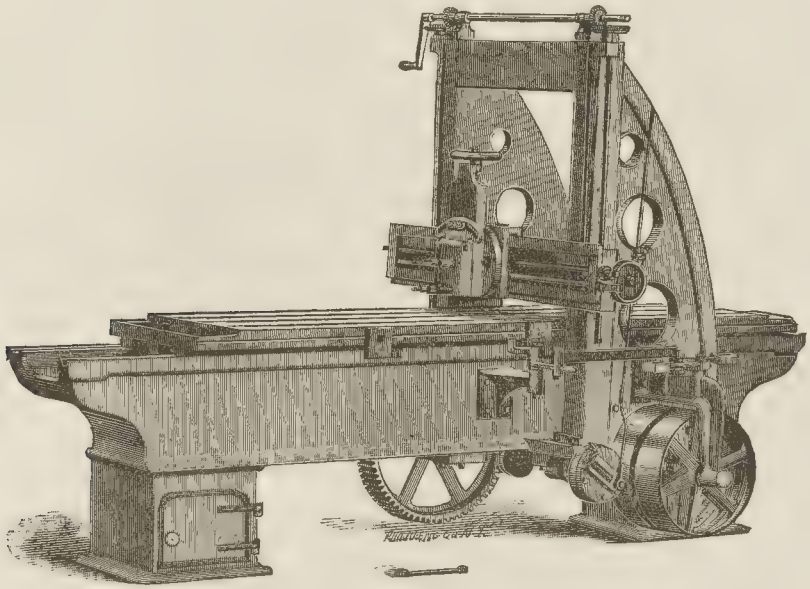


Fig. 231.

and thus reciprocates. The larger machines have vertical surfacing holders upon their uprights. For the convenient holding of work the tables or platens are cast with a large number of **T**-holes. **T**-slots are often planed in the top in addition. Upon the under side of the table are two longitudinal **V**-guides, planed and scraped, truly parallel. These **V**'s rest in corresponding ways in the bed, and guide the motion of the table in a true straight line. The table is often cast with the top side up, in order that any blow-holes or defects may come in the upper side, so as to secure the soundness of the **V**'s. The trough-shape of the lower **V**'s enables them to retain the oil necessary for their lubrication. This could not be done were the arrangement of the **V**'s reversed. To insure the lubrication of all the bearing-surface of the guides, curved channels are chipped out from the faces, running from the bottom of the **V** to near the top. By this means the oil is carried to those places from

which it would naturally drain off. It has been suggested to use flat, thin disks, which might turn in counterbores in the ways and effect the same purpose. To catch the oil which would be displaced from the ends of the V's a cell or pocket is put at the ends of the troughs, and one designer planes a bead on a flat at the top of the troughs to prevent loss of oil over the sides. An objection to the use of the two V's results from the difficulty in securing perfect parallelism of the four planes of the guides throughout their whole length, or of retaining that parallelism where the surfaces wear. If there is any difference in the hardness of different parts of the bed and table castings, the wear at different places will be uneven. If this wear be on one side of the V's, the table will crowd over and produce curves on vertical cuts. If on both sides, the table will either dip or wind, producing errors of horizontal surface. To avoid the tendency of the bed to creep and bear a little harder on one side of the V or the other one designer uses one flat and one V groove. The bearing area of the two is calculated carefully to compensate for the different angles of resistance to the downward pressure (Fig. 231). A form of planer with two flat shears offers certain points worth noting. The surfaces for wear and bearing are large and are easily made true. Side-play is prevented by adjustable gibs. Special oiling devices by flanged rollers counter-weighted so as to lift oil against the under sides of the slides prevent dry seizure of surfaces, and they promise excellent results of exactness and durability.

The bed of large planers will rest directly on the foundation, which will oppose any flexure from the strain of the weight or the cut. On the smaller sizes the bed must be made deep enough so as not to sag between the legs or supports which lift it from the floor. There has been considerable improvement in this respect in the newer designs. A very excellent arrangement is to lessen the span between the legs by making them columnar and hollow, to serve as tool-closets. The ends of the troughs are strongly bracketed out beyond the legs for the same

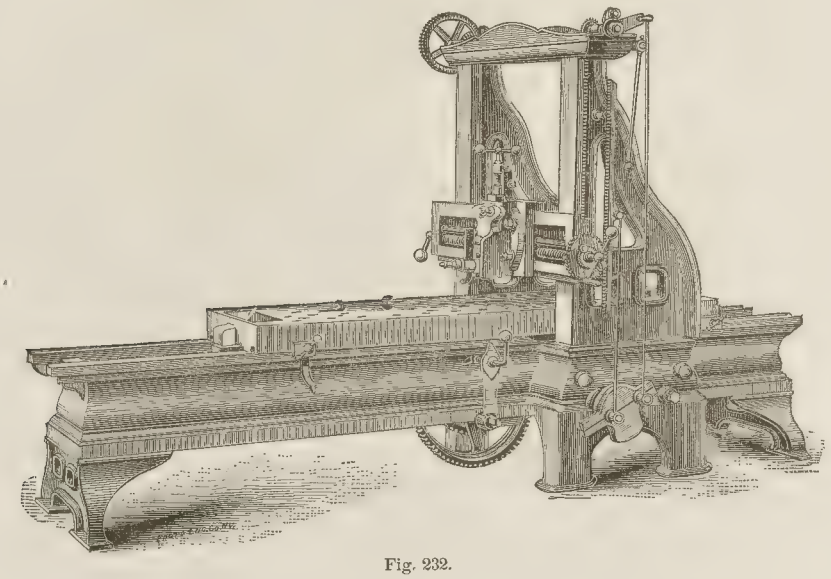


Fig. 232.

object, since the heaviest strain will always be upon the length between supports, and by the use of brackets the legs come nearer together, with a given length of trough. The bed must also be longer than the table, for while it is not necessary that it be twice as long, yet there must be no tendency for the table to tip when loaded at one end. By making the table itself deep the pressure is distributed more uniformly, and the tendency to spring is diminished. The uprights or cheeks have to resist a strain tending to bend them backward by pressure against the cross-head. This pressure will have the greatest leverage when the cross-head is near their top, and therefore the uprights will be of greatest depth and section near the bottom. There has also been great improvement in the design of these uprights with regard to stiffness. The amount of metal and its disposition is much more judicious than in the earlier forms. Openings are made in the cheeks for lightness of their web, considered as a girder, and to enable the operator to look through them at the work. The uprights are bolted very firmly to faced surfaces upon the sides of the bed. They are united by a strong girt at the top. In older practice this was an entablature bolted to the top of the sides. In modern designs the girt is cast as part of the uprights, or bolted to their sides, and is curved horizontally to act as an arched brace, to stiffen further the uprights and distribute an unsymmetrical pressure more equally on both. The uprights are put a little behind the middle of the length of the bed, in order that in front of them may be a clear space for securing and examining work. They are faced on the front side for the bearing of the cross-head, and upon some rear surface to admit of clamping the cross-head by a gib. This

clamping surface may be either an outside flange or one made by a slot down the face, which divides the bearing surface into two parts. The cross-head is upheld and adjusted by two screws, which are coupled together by a horizontal cross-shaft overhead through pairs of bevel-gears. By turning the horizontal shaft by a crank- or hand-wheel the two ends of the cross-head are raised equally at once, and require no repeated adjustment. In the larger tools this cross-shaft is driven by power, usually by a belt-wheel. Since the weight of the cross-head and attachments are opposed to the strain of the cut the screws can be used to reinforce the clamps. After the head is secured in place by the clamping-bolts, an attempt to screw down the screws will take up all lost motion and give extra points of resistance. On account of the necessary play in the number of joints, it is not generally thought judicious to attempt to feed downward by the adjusting-screws. It has been done (Fig. 232), but recent practice

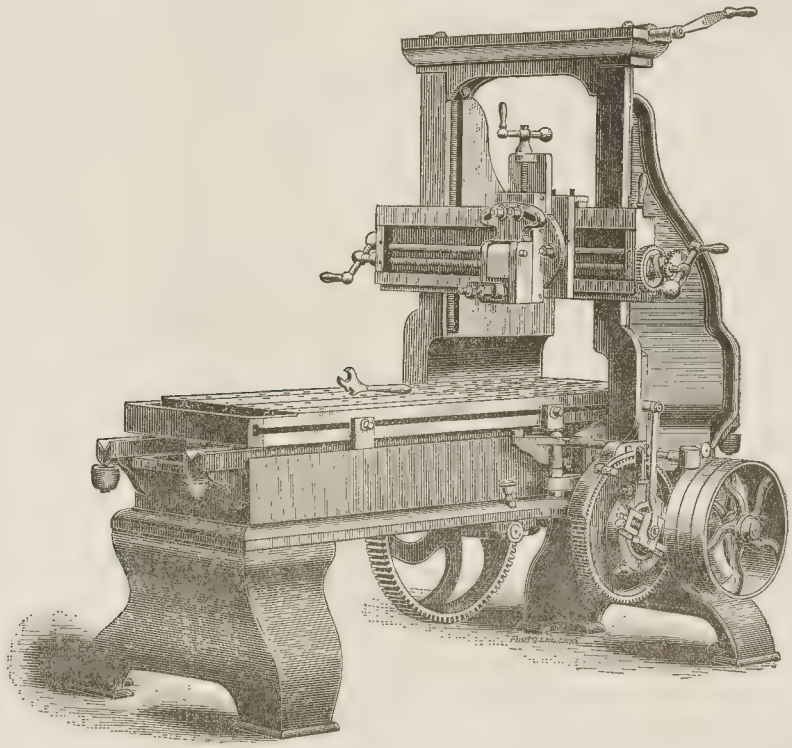


Fig. 233.

prefers to clamp the cross-head, and give all the vertical feeding at the slide to the tool-point and apron. The clamping is usually effected by two bolts at each cheek, which tighten a gib or plate, clasping the faced guide surface of the upright. The lifting-screws are carried either inside the uprights when they are of box-form, or outside of them at the back or sides. In the former case the projecting lugs which form the nuts pass through slots in the upright and serve as guiding-slides. In the latter arrangement the nuts are often separate and are bolted on to the back of the head. The uprights are often arranged so as to carry extra tool-holders (Fig. 248) for vertical surfacing.

The cross-head itself must be straight. It is very often strengthened against flexure sidewise between the uprights by stiffening-ribs at the back (Fig. 235). To lighten the web of its depth, holes are often cored out in the casting in the central part. Since it is designed to carry the slide or saddle which holds the tool stiffly and yet permit the feed-motions, there must be a track or shear planed on the front surface, in order that the saddle may be gibbed to it. These shears appear in three different forms. The upper part is made square, to resist the pressure due to the weight of the saddle (Fig. 233). This embraces the square on the top and front and rear, the top and rear bearing being gibbed to take up wear and lost motion. The under side of the shear is planed to a **V**, sloping inward and upward. In the second form both upper and lower surfaces are inclined inward, and the third form has the upper and lower **V** parallel, the lower face in all cases sloping upward and inward. The first form is by far the most prevalent, though some very excellent designs retain the second. The squared surfaces oppose the strain on them by normal resistances, and therefore move more easily than where there may be a wedging action.

The lower **V** resists the upward oblique strain of the cut, and prevents any jarring by its shape. The gibs are adjustable by screws bearing against them in shallow counterbores, or else they are tapered, and adjustable by screws and jam-nuts.

The front of the track is flat and of sufficient breadth to resist the horizontal pressure. What surface is not required between the top and bottom rail is cut away, and accommodates the rod and screw for the feed-motions of the saddle and apron (Figs. 234 and 235). The saddle fits upon the track on the cross-head, and has a horizontal motion upon it. The saddle is either rectangular, as in the cut, or in more recent practice has wings at the top for increasing the length of bearing surface, thus diminishing wear. Into the back of this saddle is secured a brass nut, through which passes the feed-screw. This screw usually runs near the bottom of the hollow of the rail, and its rotation in either direction will accordingly carry the whole saddle across the table. The front of this saddle-plate is finished off with a boss and a circular **T**-slot, into which bolts may fit, by which a swivel-plate may be

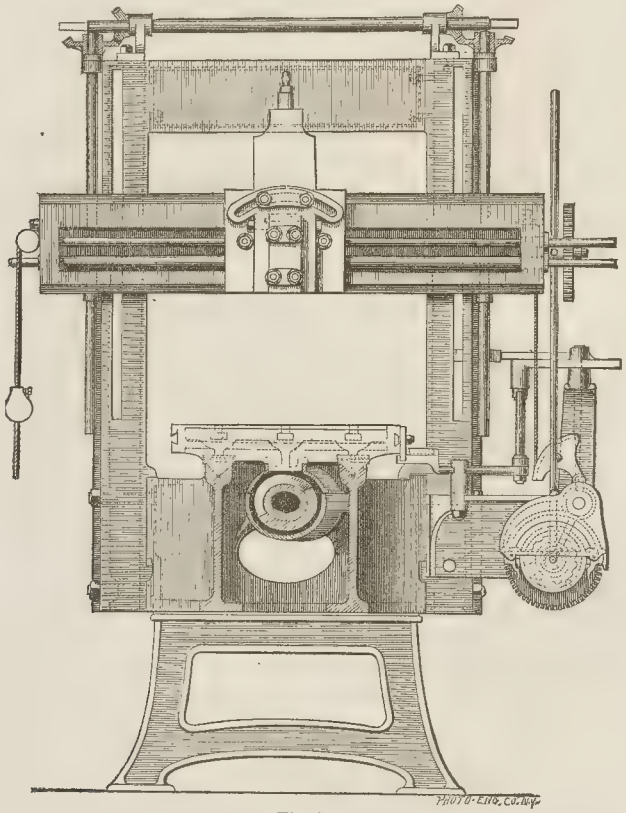


Fig. 234.

secured in any angular position. This swivel-plate carries a second flat shear, planed on its edges to a **V**, sloping inward. Upon this guide is gibbed a slide, to which the tool is secured. The slide is fed along the guide at whatever angle it may be by a screw with ball-handle or hand-wheel. To produce this vertical or angular feed of the tool-slide is the object of a splined shaft which lies along the hollow of the cross-head above the screw. This shaft carries a bevel-gear which drives a short idle shaft of bevel-gear in the axis of the swivel-plate. The third gear turns a fourth upon the axis of the downward feed-screw, so that rotation of the splined shaft will turn the screw of the feed at whatever angle the latter may stand. The fourth gear will roll around the circumference of the third when the swivel-plate is adjusted. The fourth gear may be splined to the angular feed-screw, or it may be made to serve as the nut for the latter. In this latter arrangement, when the automatic feed is in use, the screw must be locked either by a friction-clamp or by a locking-pin. When fed directly, the friction of the splined horizontal shaft is the dependence for holding the nut. In the former arrangement it is not expected that the direct feed will be much used. In fact it is not. Very often in large tools the top of the saddle is out of reach, and in smaller ones the end of the cross-head is more accessible without reaching over the work. The ends of the screw and the splined shaft are squared to receive crank or ball-handle when feeding by hand.

The power-feeds are intermittent, as they should be. The cutter, after being set, makes a stroke with the feed at rest, thus cutting always in lines parallel to the guiding V's. The feed-shafts are fitted at their ends nearest the operator to receive a loose gear. This gear carries a pawl or dog, which may turn a slip-gear in one direction or the other. Motion is imparted to the loose gear through a small angle from a slotted crank, the variation in the amount of feed being caused by greater or less length of crank. A link from the adjustable pin of this crank gives

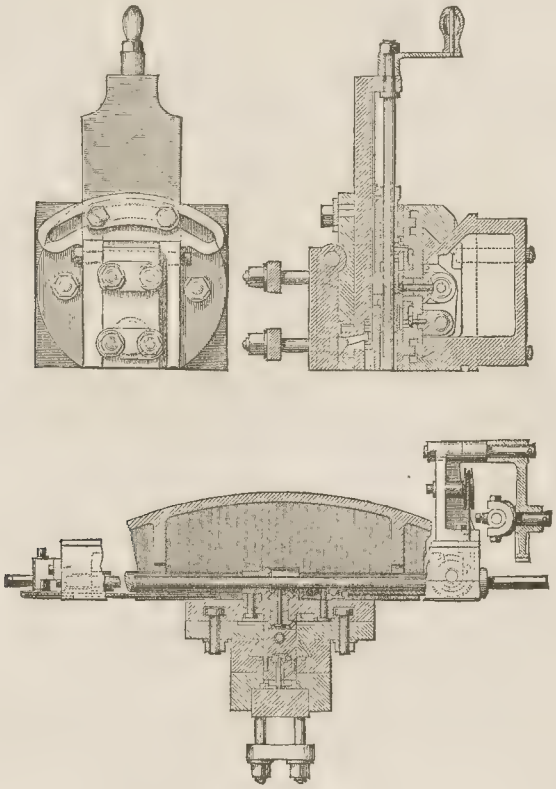


Fig. 235.

an alternating motion either to a rack, which thus turns the loose gear, or else to a sector, which acts similarly. The reason for the use of the rack is that thereby the cross-head may be at any elevation and yet the feed mechanism will be always in gear without adjustment from the operator. Where the sector or its equivalent is used, the link which moves it is clamped to it by a short-set-screw, which must be loosened when the cross-head is to be reset.

In the type shown in Fig. 236 the adjustment for height is permitted by the vertical shaft with a spline. Motion is imparted to it by partial bevel-gears. The reason for using geared transmissions is that if jointed linkages were used the leverage of the ratchet would be continually varying, and a coarse feed would be impossible with a compact arrangement and short levers. The slotted crank, from which motion is received for the actuation of the pawl, should be made as part of a wrist-plate, so that the pin in the slot may be on either side of the center of motion. This is necessary, because the stroke of the link in which the pawl slips over the teeth of the wheel must always be made at the end of a cutting traverse of the bed. Otherwise, before the return of the bed under the tool the feed for the ensuing cut would have been made, and great wear of the cutting-edge would ensue. Hence the acting stroke of the feed must be on the lifting or falling stroke of the dog according as the feed of the tool is in one direction or the other. There are but few tools which do not permit this adjustment.

This alternating motion for the feeds is either received directly from the driving mechanism or from some of the levers which control it and make it automatic.

The earlier driving mechanism consisted of a screw in the middle of the bed, whose long nut was made part of the table. The screw was square-threaded, of quite steep pitch, and was turned at one end by bevel-gears from a transverse shaft. These gears had to be small, in order that the rear end of the table might pass over them when planing long work. To effect the quick return of the table on the stroke when the tool was not cutting the

screw carried two bevel-wheels of different diameters, driven by two others of corresponding diameters, whose axes coincided with that of the transverse shaft and were on different sides of the axis of the screw. Of these latter bevel-wheels one was keyed to the transverse shaft, and turned the wheel of largest diameter on the screw. This was driven by the outer belt-wheel of three equal wheels, which was keyed also to the transverse shaft. The

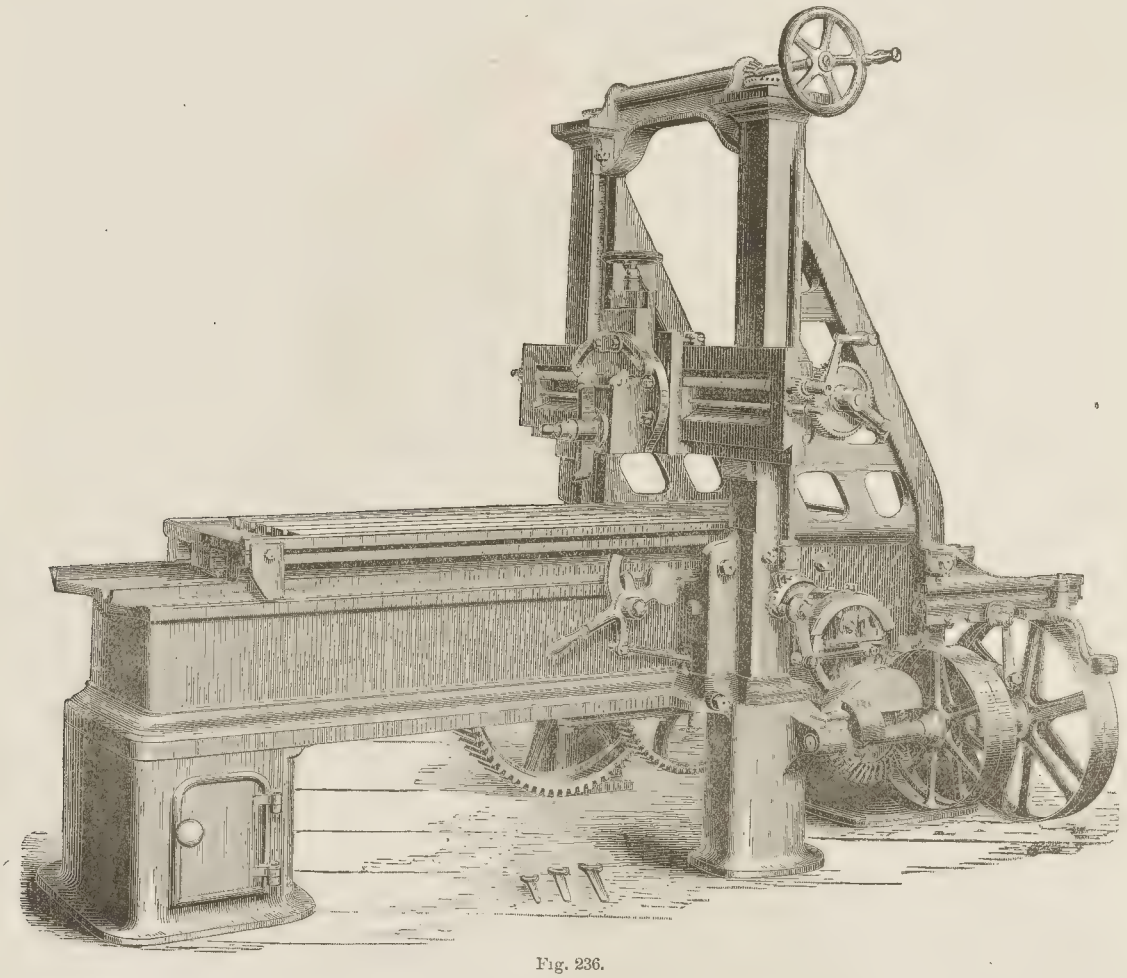


Fig. 236.

other bevel-wheel geared into the smaller wheel on the screw, and instead of being fast on the transverse shaft was secured to a sleeve, turning freely upon the shaft. To the sleeve was also secured the inner belt-wheel, while the intermediate third wheel was loose. It will be seen that while the driving-belt was on the outer wheel the screw would turn slowly with leverage for the cut. When the belt was shifted to the inner wheel, the screw would turn faster and with less leverage in the opposite direction, thus producing the quick return. The idle loose wheel is necessary that the belt may not be upon two pulleys at once which move in opposite directions. The shifting of the one belt from one pulley to the other was effected (and still is) by a pair of dogs or chocks, which bolt at any point in a T-slot planed in the side of the bed. These dogs strike an arm, which gives the transverse motion to the shifter-eyes by a bell-crank. The inertia of the moving bed, coupled with the high speed of the belts, renders the stalling of the machine with the belt on the loose pulley practically impossible. In place of the screw of the earlier types modern practice approves a rack in the middle of the table, driven by a spur pinion. This rack, in the best practice, is cut out of the solid. In the smaller tools it is a plain rack with linear teeth. Some of the larger use a rack and pinion with V-teeth. The object of this is to gain the advantage of strength which comes from large circular pitch, while securing the smoothness of motion which comes from smaller circular pitch and greater numbers of teeth. Something of the smoothness of helical gearing is obtained without the sidewise thrust which they produce. Any sidling is counteracted by the convergence of the lines of each tooth. The

pinion which drives the rack is driven by a train of gearing from belt-wheels. This train will differ according as one or two driving-belts are used in any one type of arrangement, and they will also differ in the arrangement. The most usual arrangement consists in a train of spur-gears, by which the velocity is reduced from that of the belt-wheels. The gears are heavy and are cut. Some are using steel castings for this train. The disadvantage of this system is that the long dimension of the tool is at right angles to the line shafting of the shop, while all the

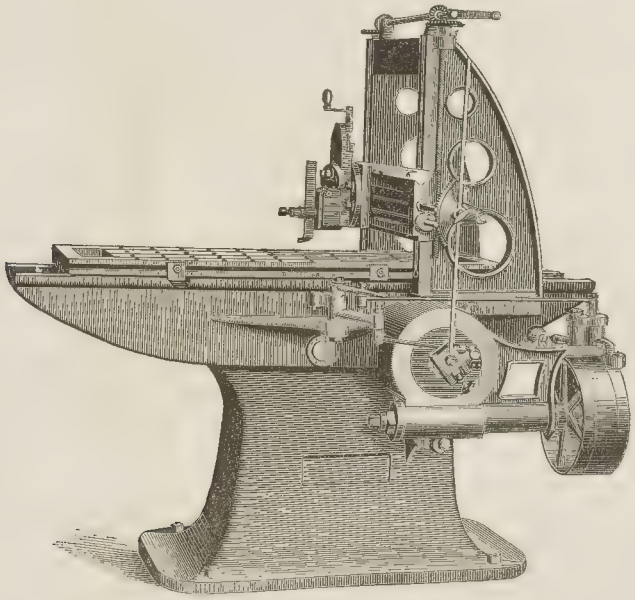


Fig. 237.

lathes are parallel to it. Hence the planers of this type are wasteful of room in a crowded shop. To counteract this difficulty the first transmission from the pulleys has been made by bevel-wheels, the other gearing being the

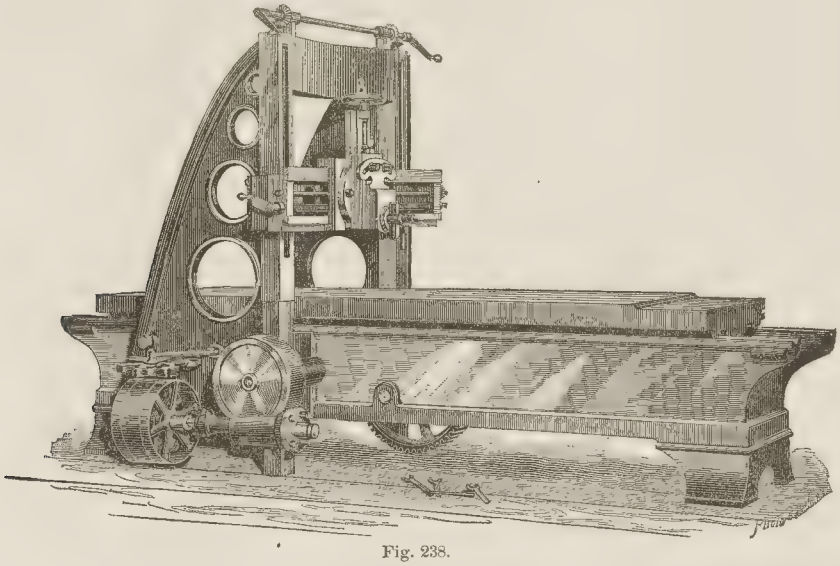


Fig. 238.

same (Fig. 236). This brings the planers parallel to the lathes. Another arrangement uses a worm and wheel at the first corner (Figs. 237 and 238). In still another the rack is driven by a worm of four threads, which has

been called a "spiral pinion", and gears the worm-shaft to the belt-wheels parallel to the bed by a pair of bevel-gears of great difference of diameter (Fig. 239). This arrangement is inferior to the one just preceding, in that

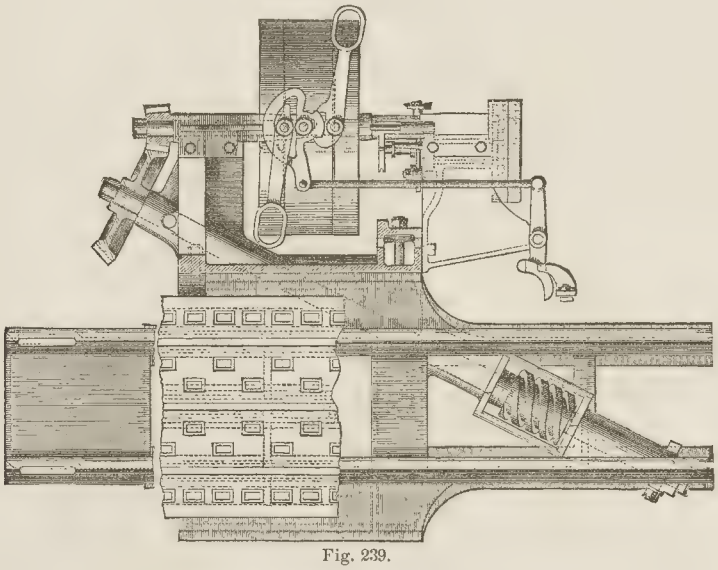


Fig. 239.

the rapid reduction of speed due to the worm takes place after the toothed gears, instead of before. The slower the gears revolve the less noise, chatter, and wear. To accomplish the quick return on the inoperative stroke of the table with two belts is comparatively simple. The usual ratio of quick return is about as one is to two; the return is twice as fast as the cutting traverse. Upon the counter-shaft above the tool are two pulleys whose

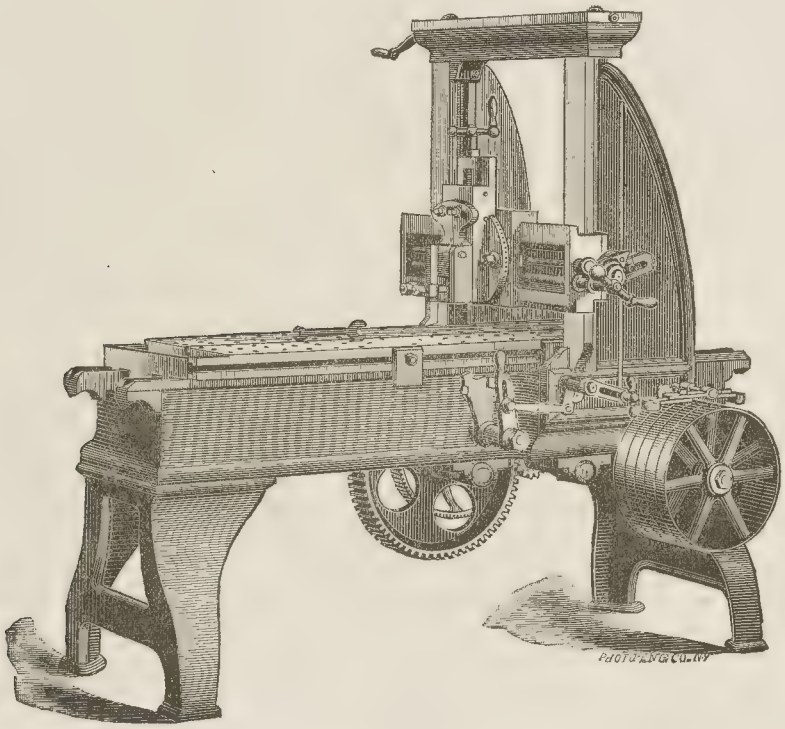


Fig. 240.

diameters are as one is to two. From the smaller one comes the belt for the forward stroke to the pulleys on the machine, while from the larger comes the belt for the return. This belt is crossed or open, according as the other is open or crossed, as determined by the shafting of the shop. The pulleys on the machine are of the same diameter usually. Where both belts are shifted at once, as in some of the smaller planers (Fig. 240), there must be five of them, the two outside and the middle one being loose. This has the advantage that the tool may be stopped without arresting the counter-shaft. On the other hand, the motion of the belt-shifters must be greater. When one belt is shifted upon the loose pulley before the other is shifted upon the fast pulley, as in the newer and better practice, but three pulleys are needed. A wide fast pulley turns between two narrower loose ones. The shifters prevent both belts from getting at once on the driving-pulley, and the shrieking of the belts as they slip in arresting the motion of the train is, to a great measure, avoided. One design has pulleys of different diameters on the machine, by which system four will be required, the two inner pulleys being loose. The system of two belts has an advantage over that using but one belt, in that the train of gearing under the machine is made simpler. Where but one belt is used, the outer wheel will be on a shaft connected to the rack-pinion by a train of gears consisting of an even number of wheels, with large reduction of velocity. The inner wheel will turn loose on the first shaft, and will be connected to the rack-pinion by a train with less reduction of speed and containing an odd number of wheels. When, therefore, there is an odd or an even number of shafts between the belt and the rack the one belt will move the table forward or backward. A loose pulley must separate the other two; therefore the tool may be arrested without stopping the counter-shaft. But the shifting-motion must be ample. Sometimes, to prevent very wide shifting of wide belts on larger tools on this system, two narrow belts were used, four pulleys were required, and each belt was shifted over only one-half the width of the wider belt which would have been required. One form of planer was made in which the reversal and quick return was effected by using external spur-gear from the inner wheel and internal gear from the outer. The internal gear moved the table in the opposite direction from that due to the external, and the speed was changed by the ratio of diameters.

For shifting the two belts in that system at once simple eyes or forks embracing the belts are secured to the rod which receives the cross-motion. For shifting them in succession a variety of devices are in use.

Fig. 239 illustrates one system in plan. There must be a separate shifter for each belt. These are pivoted near the end which is farthest from the belt-eye, in order that a small motion of the shifter-lever may move the belt over a larger distance. The link from the lever, which is moved by the dogs on the table, is attached to a lever vibrating horizontally around a fulcrum-pin. This lever has a tooth shaped on one side, which engages in a space formed in the side of one shifter. This tooth is so shaped as to move the shifter, and after escaping the corner of the space to lock the arm from moving. On the other side of the fulcrum is milled out an internal tooth or hollow cam, which acts upon tooth-like projections upon the other shifter. These profiles are so located with reference to each other that on both forward and backward stroke the belt which has just been in action shall be shifted first upon the loose pulley. Otherwise, large belt-motion would be required.

Another device is shown by Fig. 241. It depends on the principle of crank-motion that the piston moves most rapidly when the crank is at right angles to the axis of the rod. The two shifters are connected by links to pins on a horizontal wrist-plate which are on radii about 90° apart. The wrist-plate receives a partial rotation from the shifter-dogs, and always stops so that the pin connected to the belt which is driving shall stop with its radius perpendicular to the link to the shifter of that belt. By this expedient, for any angular motion of the wrist, the driving-belt will be shifted farthest at first, and may be off the fast pulley before the other is moved on.

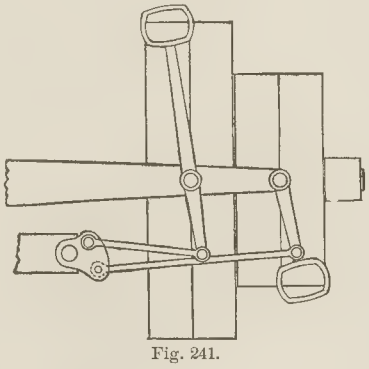


Fig. 241.

Another device has a vertical pin upon the tail of each shifter, which is moved by a groove in the lever from the shifting-dog. This groove is so designed that the pins shall be moved successively upon each reciprocation of the lever (Fig. 245).

In another design a slide receives a motion greater than that required to move the shifters. Truncated pyramids on each side of the slide engage with the double rocking tails of the shifters. The excess of motion of the slide causes the motion of the shifters to be successive, and the upper bases of the projections lock the tails of the latter. In another device the sliding-plate from the dogs has two inclined grooves in it, which operate pins on the shifters.

The planer shown in Fig. 242 adopts a principle different from any of the foregoing. There are two pulleys loose on the spindle. The middle wheel is a double-friction clutch, which may be engaged with either wheel by a slight longitudinal motion, so that the arbor will be turned either by the open or the crossed belt and at the suitable speed. The clutch is moved by a pin on a sleeve upon which turns the inner belt-wheel. This pin receives its motion from a slot cut diagonally in a short sleeve. This sleeve is rotated on its axis by the table dogs, which rotation causes the pin to slide up or down the incline and to throw the clutch in one direction or in the other. This arrangement causes the reversal to be very quiet and instantaneous.

To insure that the shifting devices shall receive equal motion on both strokes of the table the two dogs are often made to strike the levers at different points. The table has less momentum on the cutting-stroke than on the return, since it is moving more slowly. Hence the dog for the motion on this stroke is often made longer, so

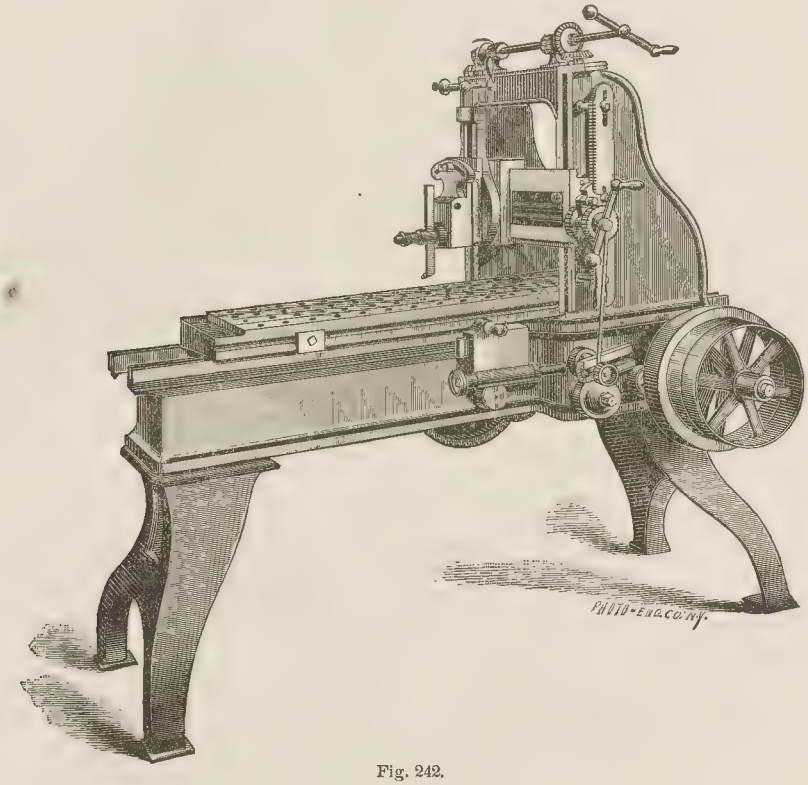


Fig. 242.

as to strike the shifting-lever nearer the center of motion. This will give the same ultimate motion as when the shorter dog of the return traverse moves a greater distance nearer the end. The end of the lever which is moved by the dogs is often arranged with a spring latch-gear, so that the latch may be sprung out of the path of the dog and permit the table to traverse farther than the limit for which the dogs are set (Figs. 237 and 243).

Without this convenience it is necessary to unscrew the dogs when the operator wishes to examine the work in front of the cross-head and tool and to set them anew when the cuts are to be resumed. The shifting-levers have usually a handle for their convenient manipulation by hand.

To obtain the single reciprocating motion required for the feed-motions in all directions is a simple problem. It is solved in two general ways. The motion is either taken directly from the levers which are moved by the table-dogs, or else it is taken from the train of driving-gears by a frictional device. This latter system is perhaps more general than the other, but it may be questioned whether it is preferred for any very cogent reason on small tools. The shifting-dogs and levers should be stout enough for their own duty, to be able to withstand the slight extra strains for feeding. The feed has only to overcome the friction of parts, since there is no cutting strain on the tool when the feed is given, and therefore the shifting-motion may be multiplied, if desirable, to have a capacity for a coarse feed for finishing. When the feed is taken from the train one of the arbors (usually the second) is prolonged outside the bed. Upon this arbor is secured a cast-iron disk, and a second disk compresses a loose washer of leather against it with any desired pressure. This pressure is made adjustable by a screw and nut. The second disk is loose on the arbor, and carries on its face the slotted crank, from whose pin the reciprocating link passes to the ratchet-gear. This loose disk is caused to revolve by friction of the leather, between stops, which permit the crank to make one-half of a revolution at each change of direction in the motion of the train. This also insures that the feed shall be given before the cut begins, and any desired power of feed may be secured by the frictional compression of the leather. The disadvantage of this form lies in the slipping of the disks while the movable one is held against the stops. This consumes a little power, and wears the disks.

Another form (Fig. 245) uses the friction due to compression of a wrought-iron split ring on the periphery of a disk. The ring is split, and is compressed by adjustable springs on the outside. An elliptical pin is fitted in the

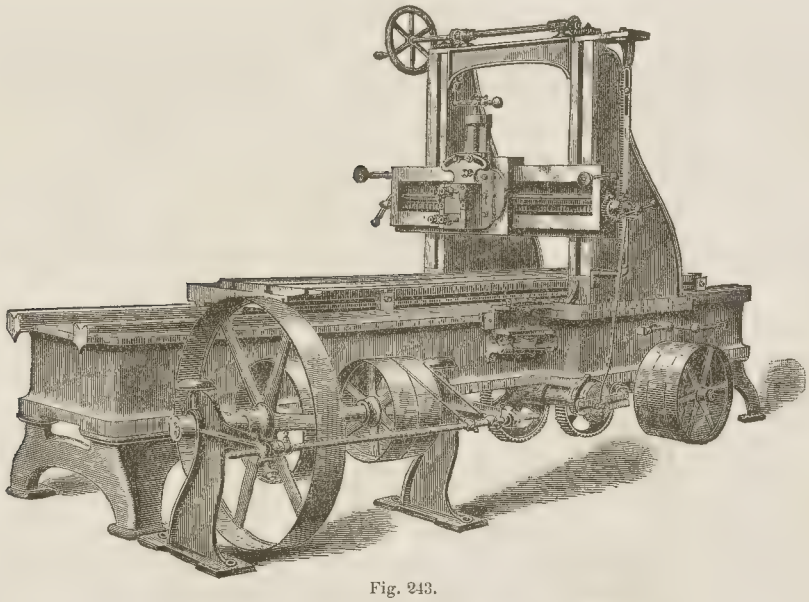


Fig. 243.

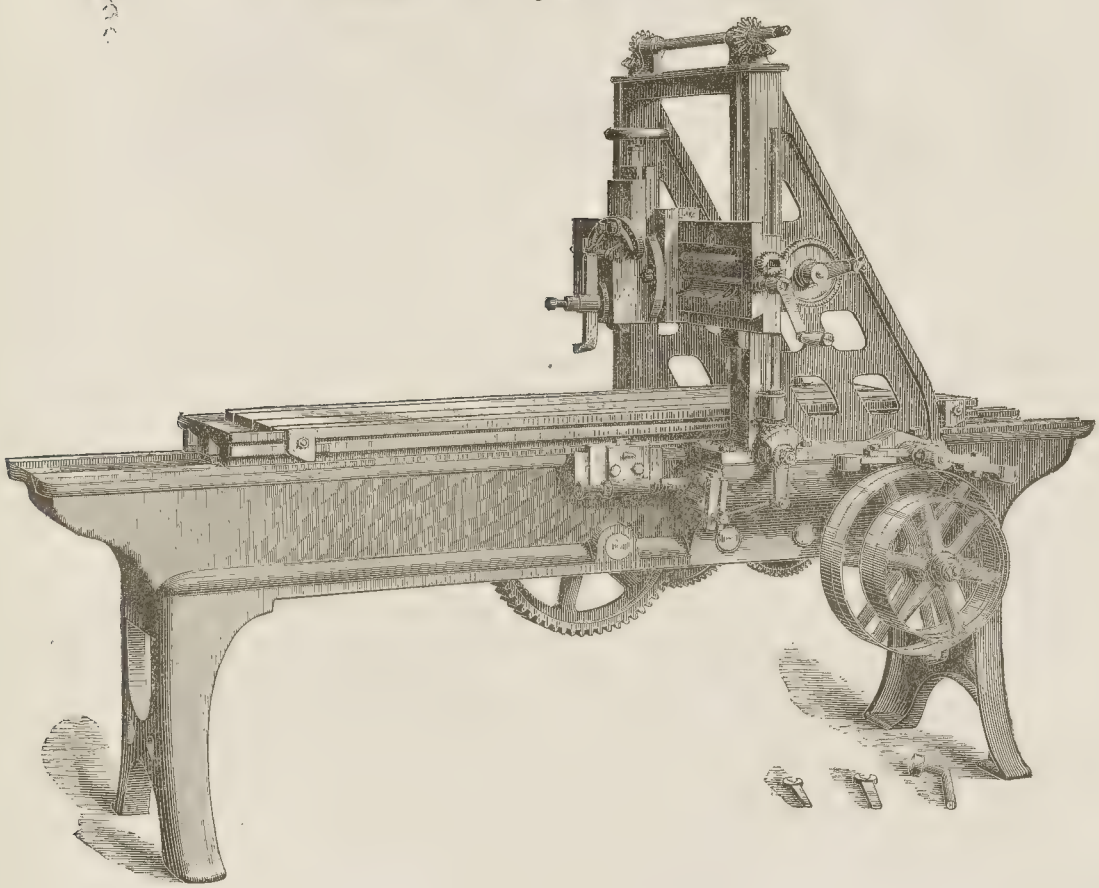


Fig. 244.

split of the ring, which is of such dimensions that the long diameter shall be sufficient to open the split and release the ring. The short diameter of the pin is enough less to permit the ring to close and establish the friction when the former is turned less than one-half around. It will be sufficient to cause the stops to turn this pin partially when the feed is made. The friction will be in a great measure released as soon as the stops are reached. A similar type is shown by Fig. 233. The friction will be engaged by the spring of the ring, when a stop no longer opposes it.

The device of Fig. 246 uses friction only to engage the pawls at each change of motion. A positive motion of the crank-disk is kept up by the ratchet-wheel until the pawl is disengaged by a positive stop. The ratchet-wheel is revolved by a pinion on the front end of the pulley-shaft.

In the planer shown in Fig. 236 the feed-motion is positive from the train, without the necessity of friction devices. A pinion on the second arbor of the train turns a half-wheel. The pinion and wheel may be toothed, or

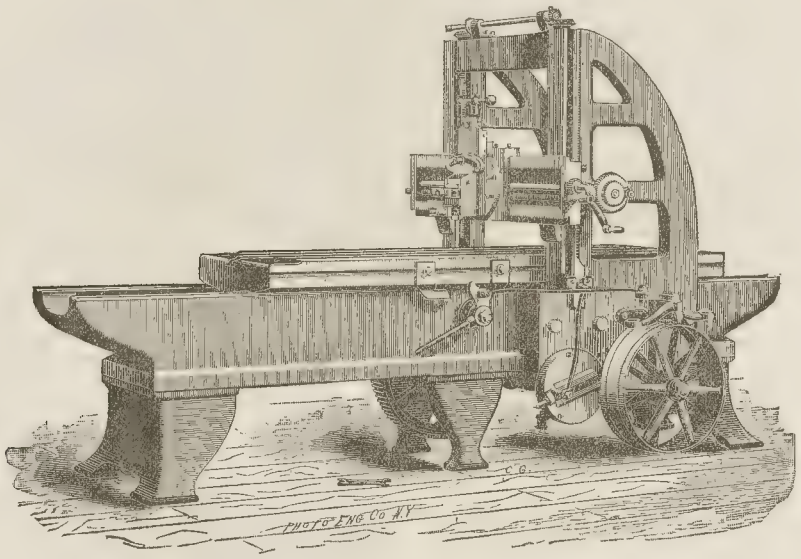


Fig. 245.

in newer practice are made of V-friction faces. The semicircle of the wheel is counter-weighted, to preserve its equilibrium. The face of the pinion is broader than that of the wheel. The last three-fourths of an inch of the face of the latter at the two ends of the semicircumference is arranged so as to be effective at the *beginning* of the half revolution, but inoperative at the end. This is accomplished by making this last fraction of the face at each end to be the end of a dog, which swings from a stud on the plate of the wheel and abuts in one direction against a stop. When the pinion on the train reverses, the dog engages with it, and by pulling against the stop the face is drawn into gear. At the end of the half revolution the dog clicks idly over the pinion, until its

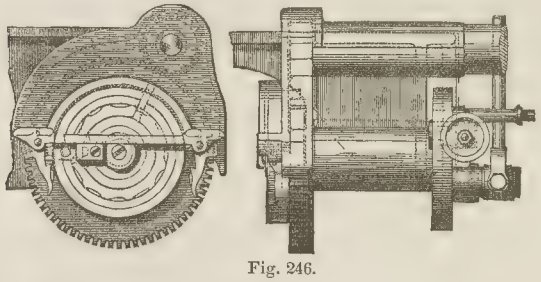


Fig. 246.

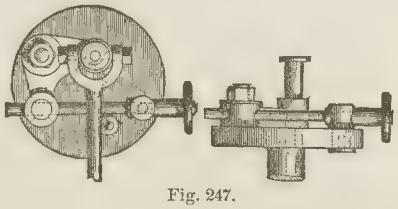


Fig. 247.

direction changes. With friction faces this clicking is noiseless. For the adjustment of the amount of the feed, while the tool is in motion, the pin on the wrist-plate is either clamped by a hand-nut or else is upon a screw. By turning this screw the pin traverses in the slot, and by it may be held at any distance from the center.

A very ingenious device for this object is illustrated by Fig. 247. The milled head on the post will move the upper end of the pivoted bell-crank, by which the pin of the vertical link will be moved and clamped nearer or farther from the center of the motion of the disk.

Were the tool held rigidly at the slide-rest, the return of the work under it would scrape the cutting-edge from behind and dull it. Hence all tools, both light and heavy, have the tool secured to a swinging apron, hinged on a conical pin between cheeks on the slide. This permits the tool to swing outward upon the return of the work, and where the tool and apron are light this arrangement is sufficient. On larger machines, with heavy cutter and

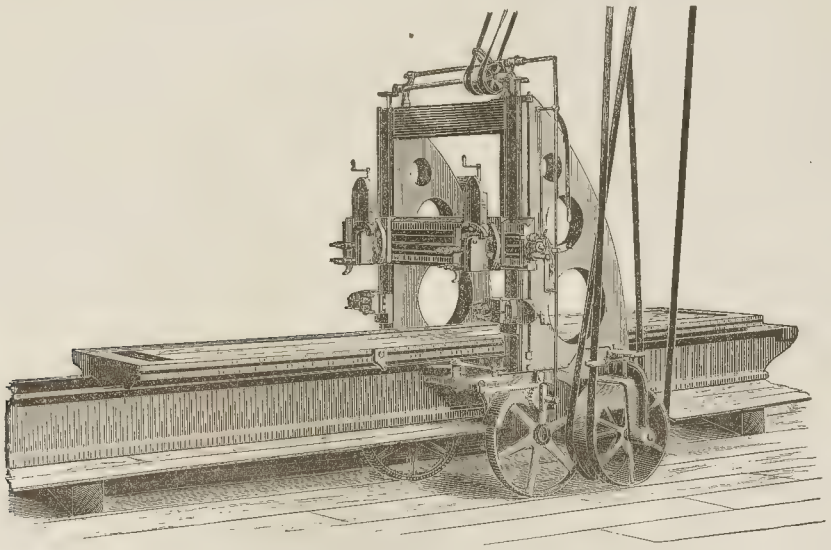


Fig. 248.

apron, the weight of the combination will be sufficient to press the edge with a grinding pressure against the work. It becomes necessary, therefore, to lift the apron and the tool by positive means. There are several methods of

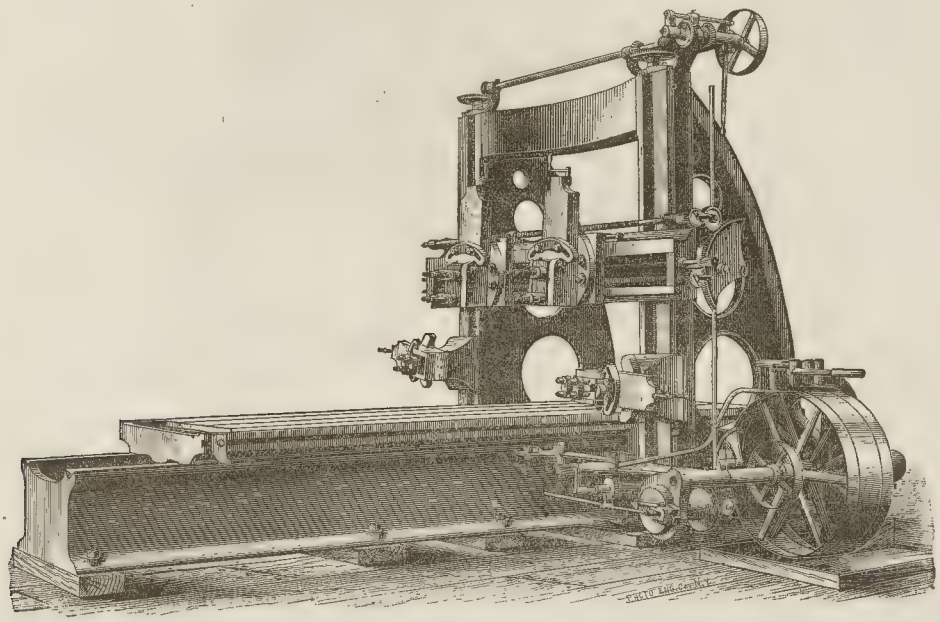


Fig. 249.

effecting this, but all use a cord over pulleys pulled by the feed-levers and kept taut by a weight. The feed-lever pulls on the cord and turns a spiral washer under the apron. The rise of the inclined plane against a twin washer

in the bottom of the apron throws the tool forward and up. When the feed-lever reverses, the weight rotates the washer back into its first position. A second arrangement makes the cord lift a knee-lever against the apron by the rotation of a disk or washer with eccentric hole. Still another has a cam on the end of a vertically-oscillating lever. All accomplish the purpose about equally well.

Planers of very large size will have two slide-rests on the cross-head, and an extra rest upon one or both of the uprights (Figs. 248 and 249). An extra feed-rod will probably be required for the second rest on the cross-head, but the rests on the uprights are usually arranged for hand-feed only. These larger tools, being designed for work of great weight from which a heavy chip is to be taken at each cut, usually move more slowly than the lighter tools, and have more wheels in the train which drives the table. The feed also has to be powerful, and the cross-head and rests must be located by power.

Fig. 249 shows the device for lifting and lowering the cross-head by two bevel-wheels, which may be clutched to the shaft of the overhanging belt-wheel to produce motion in either direction. These larger tools are usually built with the rack with V-teeth. In these longer trains of gears there is more chance for back-lash in the teeth, which produces, with the elasticity of the belt, a disagreeable intermittance of the motion of the table, which is fatal to the exactness of some work. The design of Fig. 249 drives the table through one pair of gears and the worm which meshes into the rack. The smoothness of the worm-motion is noticeable, and the obliquity of the passage of the worm-shaft through the bed-casting prevents the weakening of the bed by its being cut open to admit of the

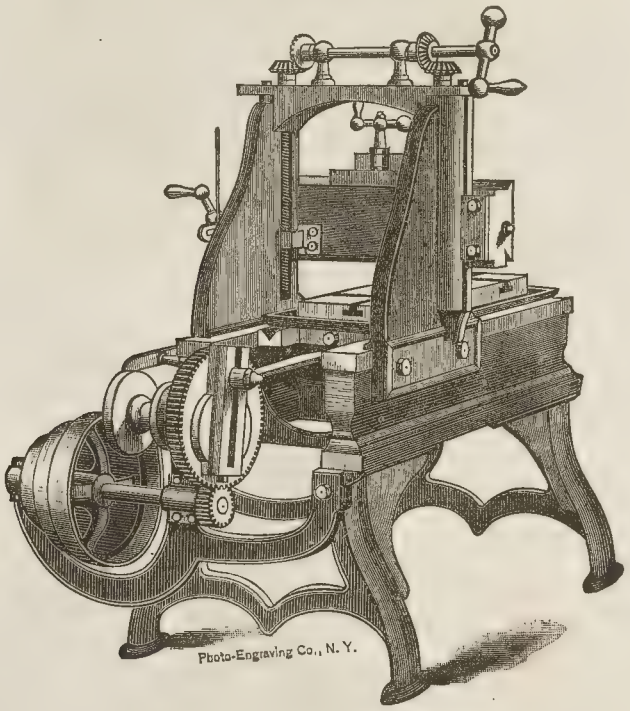


Fig. 250.

gear-train arbors. The rack-teeth are straight, but inclined at about 5° to prevent a tendency to sidewise motion. The thrust of the worm-shaft under the cut is borne by a step-bearing in the rear side of the bed, and that of the quick-return motion by hardened steel collars. The other features are common to the smaller designs of the same builders.

For small work, where the speed may be increased, a great deal of work can be satisfactorily done upon crank-planers. The bed stands high upon legs, and instead of being driven by screw or rack, it is reciprocated by a slotted crank on the cone-pulley shaft. The stroke is adjusted for length by the position of the crank-pin, and for speed by the cone-pulleys. This adjustment of speed is made necessary by the fact that without it the table would move over its travel in the same time, whether the stroke were long or short. This would make the cutting-speed to vary between too wide limits.

The crank is either of the ordinary form, or else of the Whitworth quick-return type, which is employed for shapers (Fig. 250). This latter device results in a saving of time. The tool is usually fed by power for horizontal

traverse only, from a groove in a cam-plate. The design of Fig. 251, however, presents all the conveniences of the larger tools. The connecting-rod eye is held in a slot in the under side of the table in these tools, its position being adjustable by a screw in front.

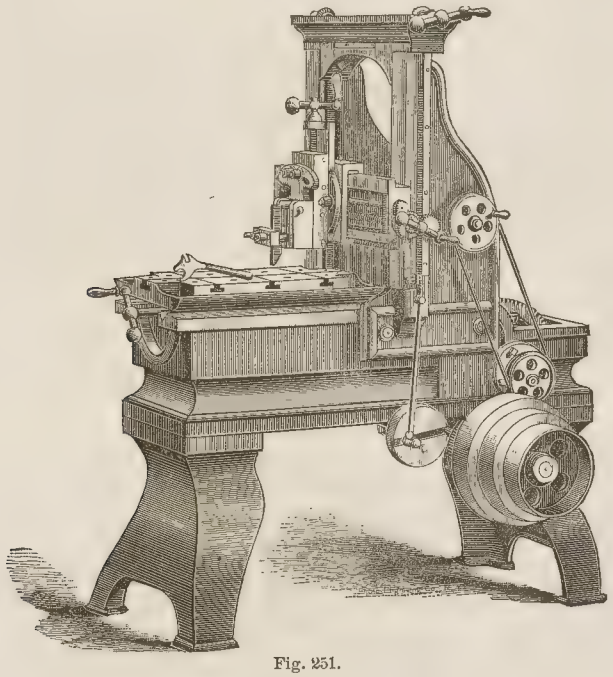


Fig. 251.

This class of machine is much used for brass work and the like, presenting some advantages over the ordinary type of planer, or the shaper, which it much resembles.

§ 27.

SPECIAL FORMS OF PLANER.

To save at least one-third of the time of planing operations as usually done, planers have been devised with two cross-heads. These are held upon two sets of uprights, which may be bolted in T-slots on the side of the bed. Both may be made adjustable (Fig. 252), or only one (Fig. 253). The former shows a novel device for feeding the

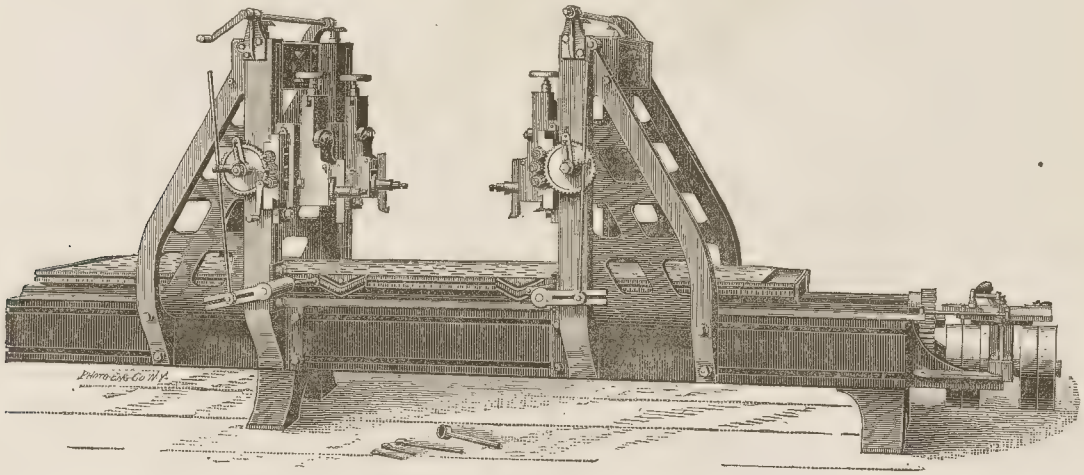


Fig. 252.

slides, and the two designs differ in the method of applying the principle of the screw for driving the bed. Each is driven by two belts. These tools are especially adapted for planing the stubs of engine-work or for other short surfaces upon long work. At least two articles can be finished at each end at once.

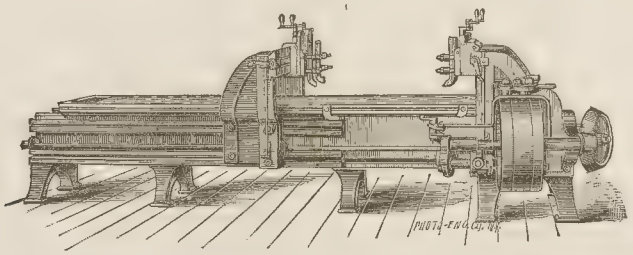


Fig. 253.

Figs. 254 and 255 show two types of machine for edge-planing of boiler- or ship-plate for calking. If not so treated the calking edge must be produced by hand-chipping, which is costly, and will not be so exact. The plate is held stationary by the long vise-jaw in Fig. 254, the two screws at the ends being worked together by the hand-

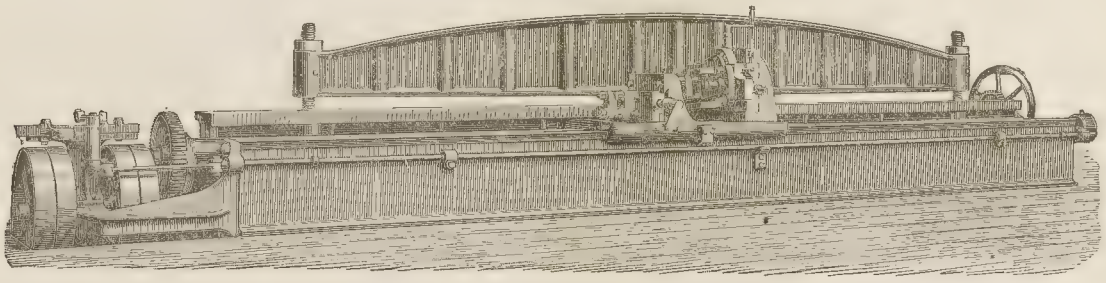


Fig. 254.

gear at the right. Bosses for set-screws are provided in the movable jaw, in case ship-plates are to be beveled after being curved. The other design clamps all work by the set-screws. The tool-carriage is fed by a long screw from open and crossed belts. It is intended to carry at least two tools, and sometimes three. Where two are used one cuts on one stroke and the other on the return. Where three are used, two cut on the forward stroke and the third makes a finishing cut upon the return. This latter has a stop provided, so that when the holes are arranged at first to be parallel with the future edge, all holes shall be at the same distance from that edge. These tools will plane plates 14 or 15 feet in length.

For special purposes attachments may be applied to any pattern of planer. One builder of large engines has applied a boring and facing attachment to his largest planer. By this means engine frames may be planed for the guides and trued at the cylinder ends with one chucking to the table. Locomotive-shops have applied false tops to the tables for planing the links of the reversing and cut-off gear on the Stephenson system. The link has a curvature due to the radius of the eccentric-rod. The link may be clamped to a vise which swings around a center in a line at right angles to the path of the tool, and at the proper distance from the center line of the slot. In another and simpler device a slotted bar bolts to the rear of the cross-head. It projects horizontally at an angle, and a slide on top of a post fits the slot in the bar, and gives the proper rotating motion to the false top.

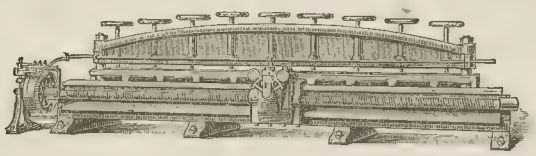


Fig. 255.

The frames and table of planers are often used for the foundation of other machines working with rotary cutters, to which allusion will be made in the sequel. For some special work on locomotive-frames an unique planer has been made, with one upright at the working side as usual, but having the other end of the cross-head carried by an arched frame. This frame is made of open cast iron, in somewhat the form of an arch. The abutments are at the ends of the bed, so that wide work may overhang the table of a smaller planer at the farther side. There are but three or four of them in use.

§ 28.

SHAPERS.

The term shaper is applied to a tool in which the planer principle is inverted. The work is held and the tool traverses across it while feeding-motion is imparted to either or both. The tool is held at the end of a long slide, which receives a reciprocating motion usually from a connecting-rod and crank. This slide is guided by a track or shears, to which it is gibbed, and is made long to resist the increased strain when working on a long stroke with considerable overhang. The tool has a quick return in most cases, either by the Whitworth gear by two elliptical wheels or by two belts from wheels of different diameters.

The principle of the Whitworth gear is shown by Fig. 256. A gear-wheel, S, is driven by the small pinion. The crank-body P does not have the same center as S, but is eccentric to the latter. Its center is C. The center of S is made large enough for the center C to pass through it, as shown by the dotted line. The crank P is not connected to the face of S, but may slide upon it as it is compelled by their mutual eccentricity. The rotation of S, however, compels that of P by the pin in the face of the former which plays in and out in a slot in the tail of the latter. Hence, when the pin is farthest from the center C, the slide connected to R will move most slowly with

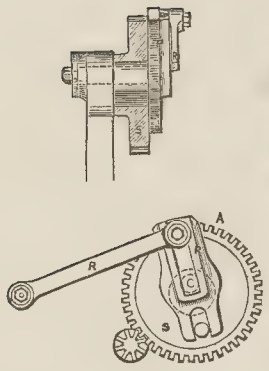


Fig. 256.

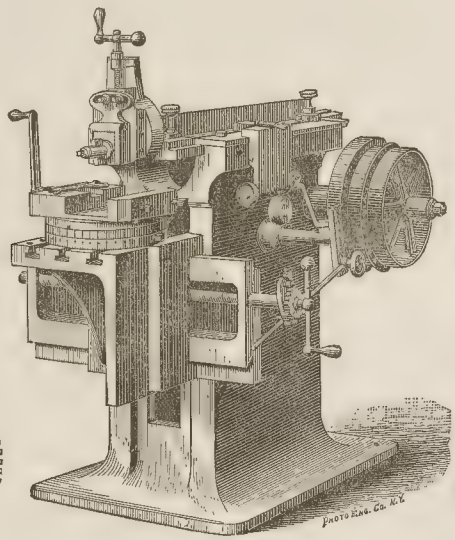


Fig. 257.

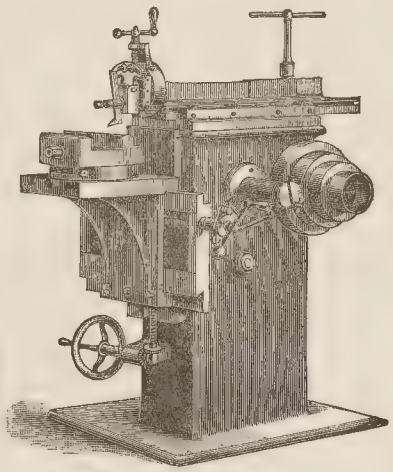


Fig. 258.

the greatest power. When the pin is nearest C the crank will turn most quickly, but with least force for the return stroke. The variation of stroke is accomplished by the slot in the crank-arm. To compensate for the higher speed of long cuts the small pinion is driven from cone-pulleys. In the elliptical-gear arrangement the wheels are horizontal, and turn around their two foci. The quick return will be effected when the long radius of the driver turns the short radius of the gear which carries the crank-pin.

The shaper shown in Fig. 257 has the tool-slide driven by a pinion which meshes into a rack upon its under side. The pinion is driven from either of two belt-wheels driven by open and crossed belts, to either of which it may be clutched by a double-friction cone, precisely as in the planer built by the same makers. This makes the tool the most direct inversion of the planer, and permits the length of stroke to be varied without stopping the machine. The position of the slide relative to the crank is made variable in the other forms by a long slot in the side of it. The pin for the free end of the connecting-rod may be clamped to any part of the slot.

The shaper appears in two forms, the pillar-shaper (Figs. 258 and 259), and the traveling-head shaper (Fig. 260). The pillar-shaper has the power-feed to the work given horizontally only. Vertical or angular feed is given by hand. The whole front has a vertical adjustment by screw and hand-wheel. In another form (Fig. 261), the slide is arranged vertically to secure stiffness from depth in the overhang. The table in this tool is made with a vertical face, to which work may also be bolted. The fly-wheel is preferred by some builders, in order to equalize the active and inactive strokes.

The older form of horizontal shaper belongs to the pillar class.

The shaper with traveling head is built for the larger services. The cone-pulley shaft is splined, and the head which carries the tool-slide carries also the driving-gear and crank. The whole head is fed by a screw along ways

on the top of the frame (Fig. 260). The feed is by a pawl and levers, and it is so arranged that the feed shall always be given at the beginning of a cut, and not at the end or in the middle. There are two tables, to which an object may be clamped vertically or horizontally, or to which any vise or centers may be applied. There is also a mandrel

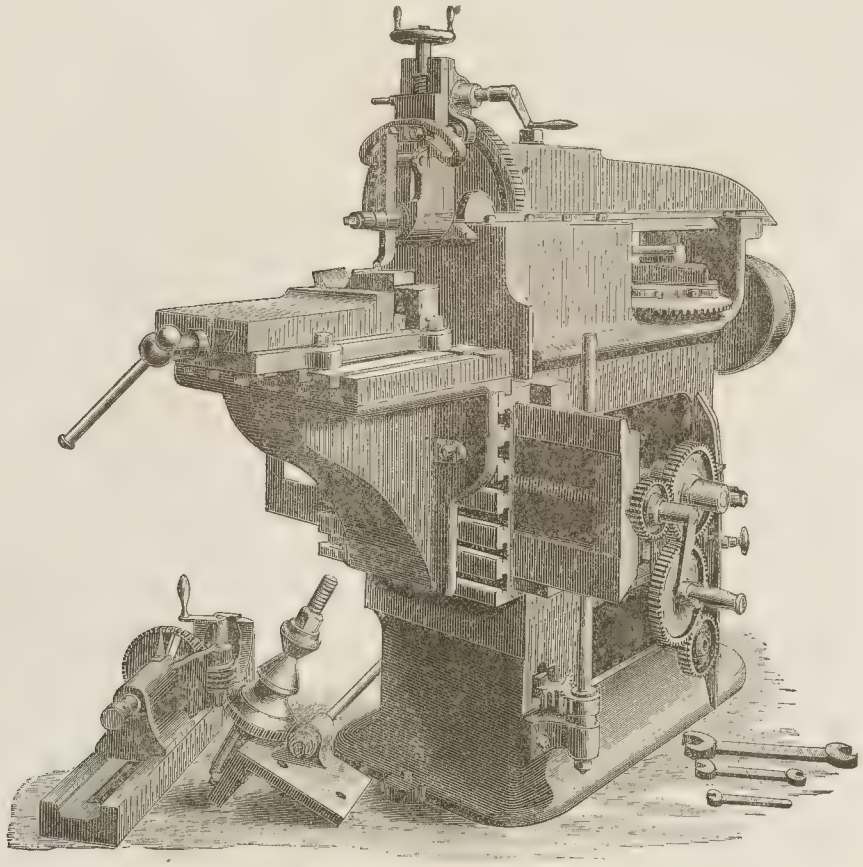


Fig. 259.

with cones for cylindrical work. The tables have a vertical feed-motion, and the tool may be fed vertically or at an angle, or may have a circular feed for concave or convex surfaces. The tool-feeds are given by hand.

Fig. 262 illustrates a similar tool, where the circular, vertical, or angular feed may be effected automatically. The stops give motion to the rod which is connected to a ratchet on the feed-screw by universal joints. The saddle, or head in this tool has quick hand-wheel traverse by the rack on the inside of its track. One of the tables is arranged to have a swivel top, interchangeable with the vise and centers. Fig. 263 shows a tool with similar capacities. Sometimes shapers are made with two heads upon one bed-plate to operate on both ends at once of long work, such as engine-rods and the like. These are called double-shaping machines.

Shaping-machines are especially applicable for small work, or for the finishing of small areas on large work. They are also adapted for finishing the curved surfaces of cranks or of levers with bosses upon them. They will also work rapidly on polygonal work, held in the centers. They do a variety of work which the planer could only do with less economy of time, and with less ease of management, beside requiring more power.

The fundamental principle of the shaper is often resorted to for work which is relatively very large as compared with the tools which are to operate on it. The work is bolted fast to the floor-plate or a bed-plate, and a tool is made to slide in front of the work and receives the proper feeds by hand. The tool may be held on a planer-bed which reciprocates at the side of a heavy casting.

A tool specially adapted for this class of work consists of two parallel rails which form the bed. Between them is a pit, in which may be laid the large work. The insides of the rails are fitted with inclined lugs and brackets, so that the work may be held and adjusted parallel to the shears on top of the rails. On the upper side of these

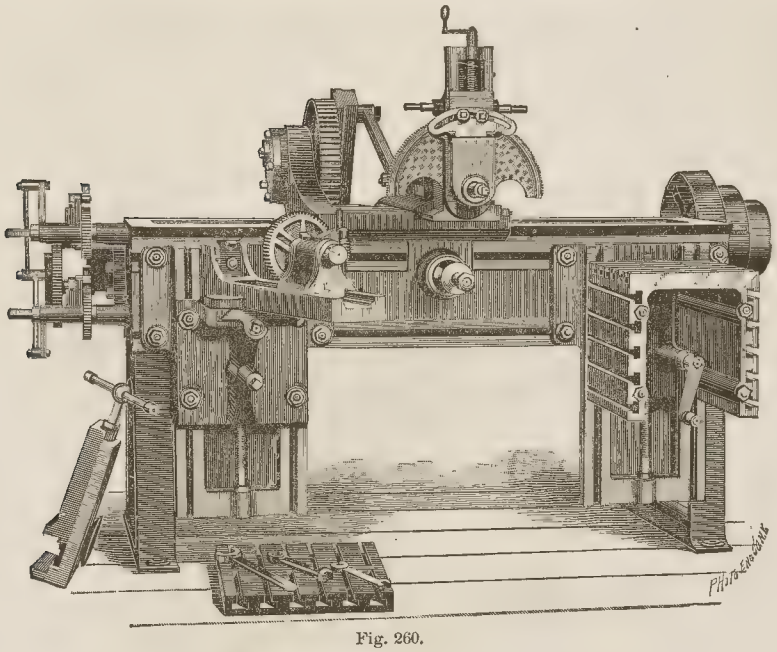


Fig. 260.

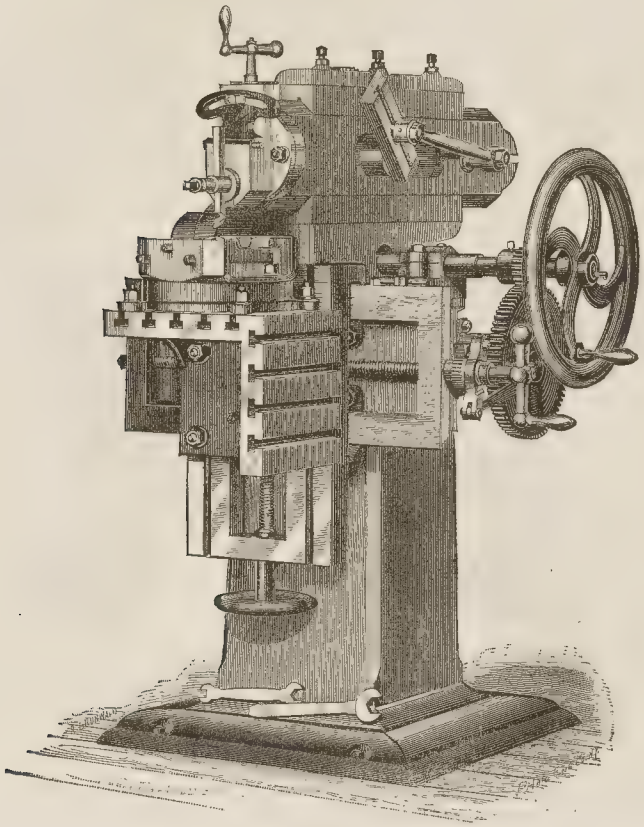


Fig. 261.

rails slides a stiff cross-rail spanning the pit and carrying shears and a saddle for holding tools. The cross-rail receives longitudinal motion along the rails by two screws between the shears of the primary rails driven by bevel-

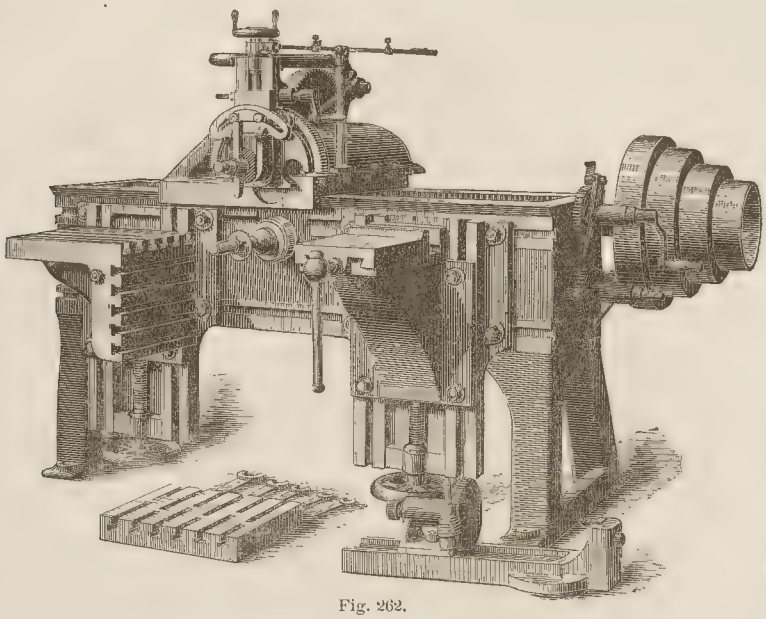


Fig. 262.

gear from the driving-shaft at the head. A very ingenious and simple form of holder keeps the horizontal screws from sagging, as the cross-rail nuts recede from the center, and so prevents jumping at the cut. This tool is particularly adapted for work upon heavy engine bed-plates.

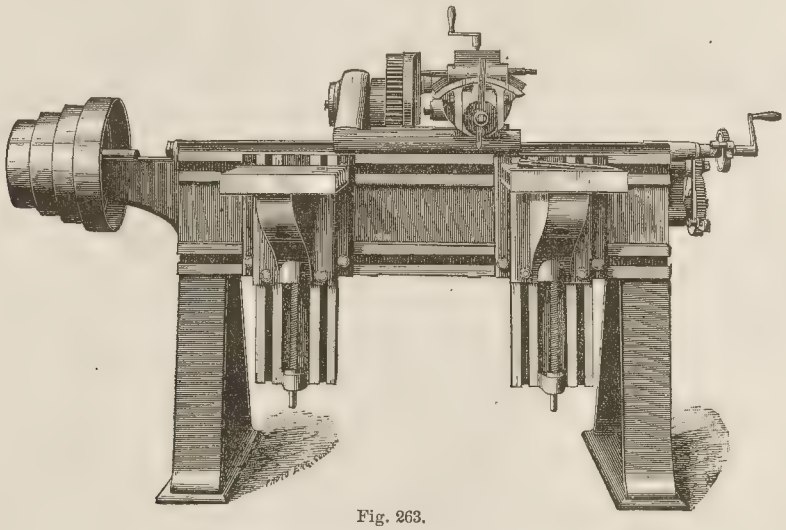


Fig. 263.

§ 29.

SLOTTERS.

The term slotting-machine is applied to a shaper with a vertical cutting-stroke. They are so often applied to the cutting of key-ways and similar vertical slots that their name has come from that one function.

The tool-slide is guided by the dovetail slides in front of the machine. In two designs these guides are adjustable, and may be brought down nearer the table to prevent any spring from the long overhang (Figs. 264 and 265). The reciprocation is derived from a slotted crank or wrist-plate, to which a quick-return motion is imparted by elliptical gear (Fig. 269) or by the Whitworth device. The slide-pin is adjustable in a slot, in which it may be clamped by a nut, or it may be carried upon a screw (Fig. 266). The tool illustrated has a convenient method for turning the adjusting-screw. The strain on the tool is in the direction of its length, consequently it needs to be clamped very firmly against the slide. This is accomplished in the smaller tools by means of two heavy set-screws. Not infrequently the cutting-edge is a simple "bit," carried in a large holder, which gives ample hold for the tool-screws. To avoid the dragging of the tool-point on the up-stroke, which its spring under the strain of the cut is certain to cause, the bit may be hinged in its slot in the holder, and fall away from the work when lifted. A

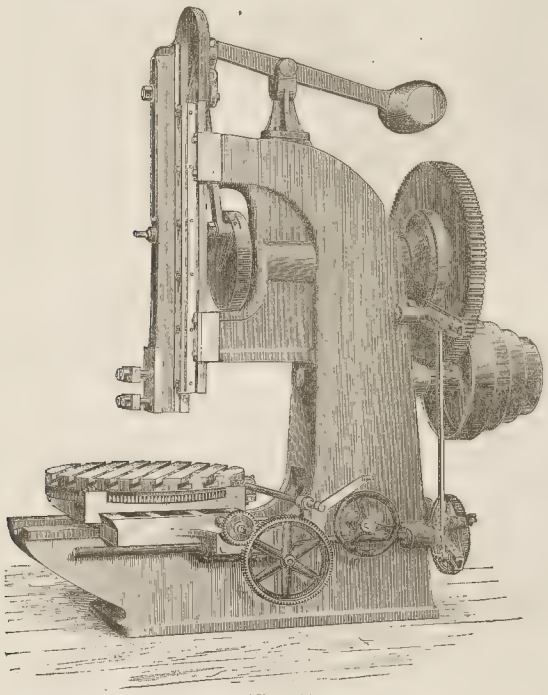


Fig. 264.

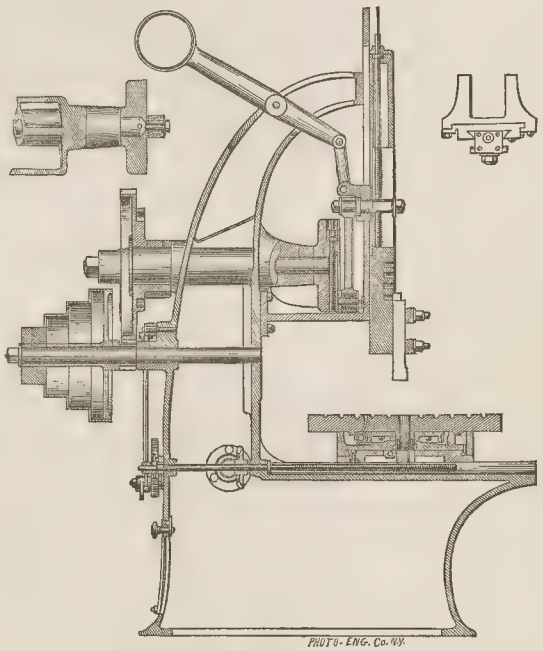


Fig. 265.

spring forces the bit against the shoulder when it is released from its work (Fig. 267). For larger work an apron may be bolted to the end of the slide, acting similarly with the larger tool (Fig. 268). In the tool shown in Fig. 269 an especial device for the relief of the tool is one of the features. On the inoperative stroke of the feed-levers a motion is given to a screw of steep pitch which backs off the work from the tool-point. When the tool is up, this steep motion is restored and the feed is given in addition by the reverse motion of the levers. In this tool, and in that shown by Fig. 264, the adjustment for the slide-pin is made by the hand-crank on the squared arbor in front. A pair of bevel-wheels turns the screw on which the pin is borne. The quick return is effected by elliptical gear.

The slotter tables have three motions. They move forward and backward, to the right and left, and in addition will turn around a center by a tangent-screw combination. To prevent undesired rotation the circular top of the table may be clamped to the upper traversing slide by grooves in its periphery. The feed is given by a slotted lever, worked by a grooved cam on the crank-shaft. This gives motion to a dog-lever, which may turn slip-gears loose or with splines on the various arbors, which work the tables by screws. The tool-slide is counterpoised by a weighted lever connected to it by a link.

Some of the larger slotting-machines are driven by a rack upon one side of the slide. This rack is either with straight teeth, or the teeth may be made of the V-shape for smoothness. The designs of this latter class have the pinion for the rack driven by a worm on the belt-wheel shaft. There are pulleys of different diameters on it for the quick return, with open and crossed belts shifted separately. The stroke is controlled by dogs in a slot of the slide. Some of the older and larger slotters attain the quick return from one belt. This is shifted from a pulley fast to a shaft which carries a small bevel-wheel, to a pulley on a sleeve turning on the first shaft, which carries

an equal bevel-wheel, facing the other way. These bevel-wheels turn others of different diameters on the first shaft of the pinion-train, and thus operate to reverse and to cause the quick return, when the belt is shifted by the motion of the tool-slide.

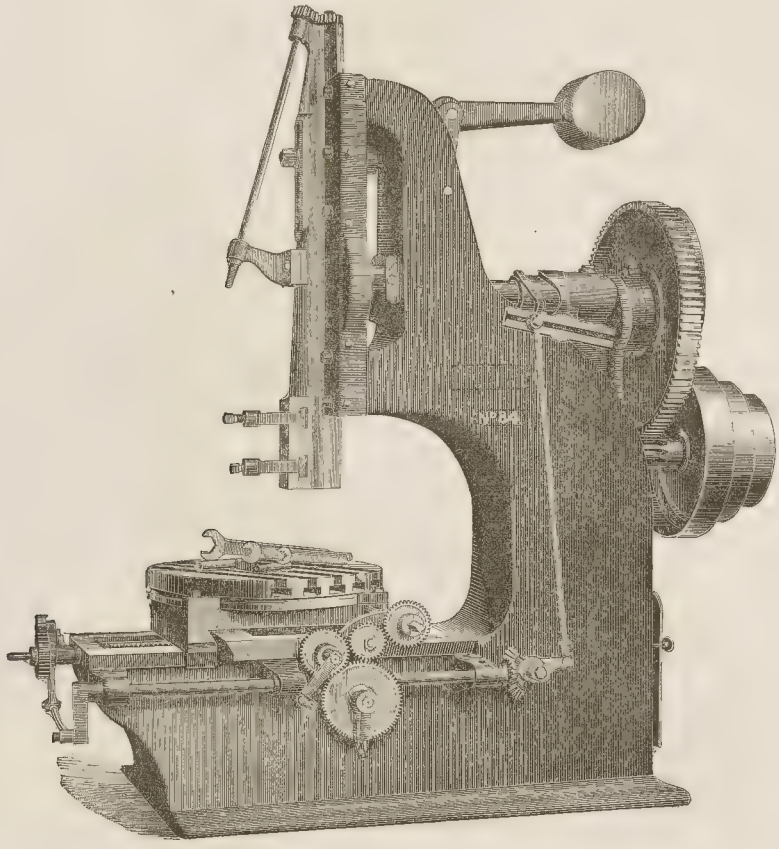


Fig. 266.

For the very largest slotters, a screw of steep pitch moves the tool-slide. On a tool of this class for the heaviest work, the piece is chucked to a heavy floor-plate, and the upright which carries and guides the holder

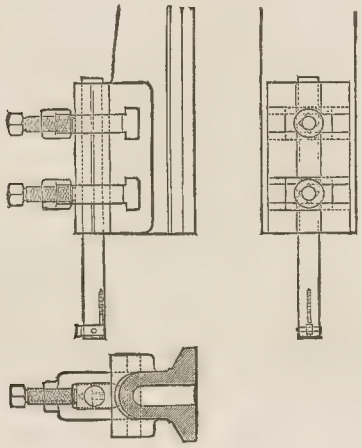


Fig. 267.

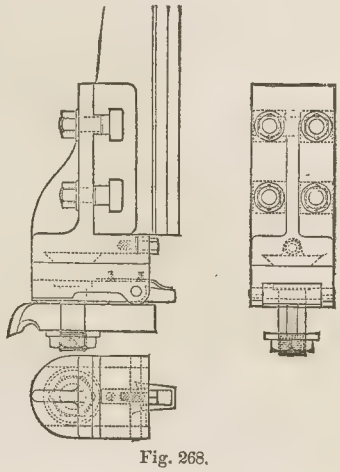


Fig. 268.

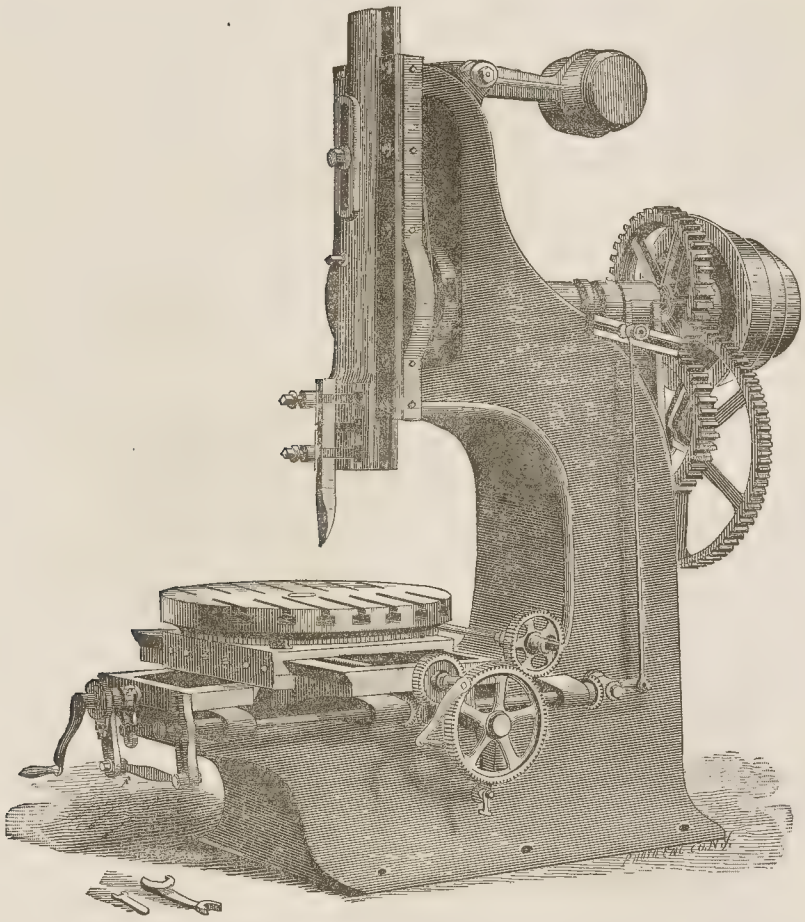


Fig. 269.

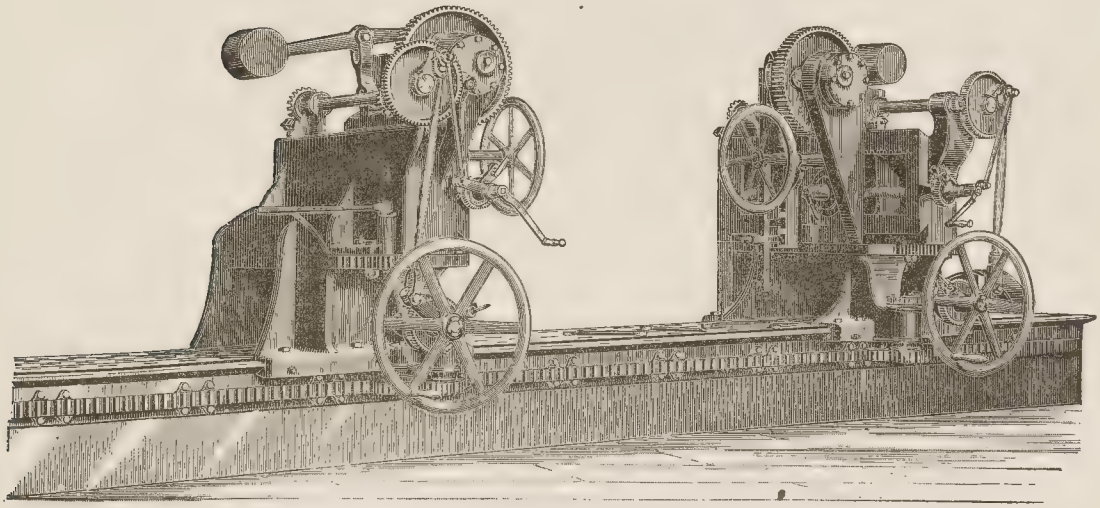


Fig. 270.

slides in front of it as fed by a screw. The quick return is given by two belts to a geared splined shaft in the bed below the upright which drives the cutting-screw. The shifting is effected by dogs on a horizontal slotted disk, and the feed is controlled by shields which may admit any desired engagement of ratchet-dogs in either direction. Some heavy slotters, self-contained, have been built with two heavy pillars bolted to the bed-plate which carries the compound table. These pillars are at the two ends of the bed, and support a heavy entablature upon which the train of driving-gear is carried. When these tools are used for heavy profiling, the cutter is pivoted in the holder between cheeks. The long tail of the cutter acts as the spring of the smaller holder previously shown, to permit release on the up-stroke, and to bring the cutter to the shoulder of the holder for the cut.

Fig. 270 illustrates a special form of slotter for dressing the welded frames of locomotive-engines. The two heads face each other, and are driven and operated separately from the splined shafts at the rear. The slide is borne upon the cross-rail, and has automatic feed across the table, while the entire head may receive longitudinal

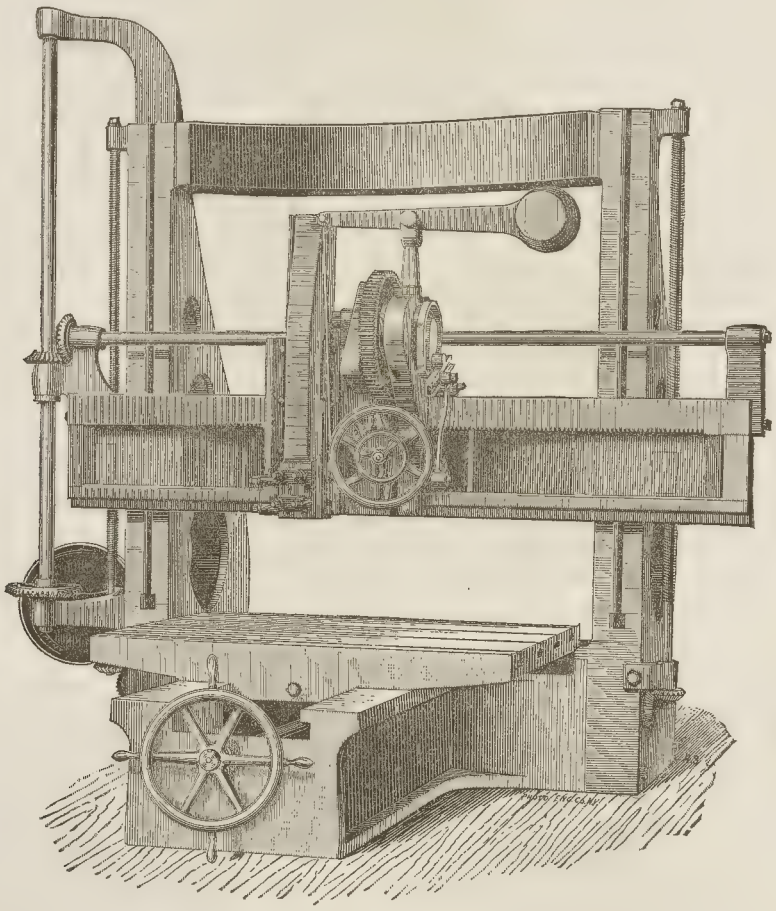


Fig. 271.

feed. The feed-cam is made adjustable upon the gear-wheel which turns the slide-crank to bring the feed in any desired relation to the end of the stroke. For slotting the jaws for the boxes of the driving-wheel axles the heads have an angular adjustment by a pinion and sector, so as to cut obliquely to the line at 90° with the axis of the bed. The saddle has a rapid motion by hand-wheel and rack.

Fig. 271 shows another form of plain traveling-head slotter. The slotting-machine is especially adapted for profiling of heavy work, especially where the profile is much broken. The work may be secured to the table with ease, since gravity assists in holding it there. The table also opposes a direct resistance to the cut, so that the strain of holding the work does not come upon the chucking devices with increasing leverage as the dressing progresses. Large cranks and similar work could be as easily dressed into shape upon no other tool, and for cutting off and cutting up scrap for reforging it serves an admirable purpose.

Fig. 272 shows a tool upon the dividing line between the slotters and the milling-machines. It is for cutting key-seats and similar work. The cutter reciprocates with a quick-return motion from the crank and slotted lever.

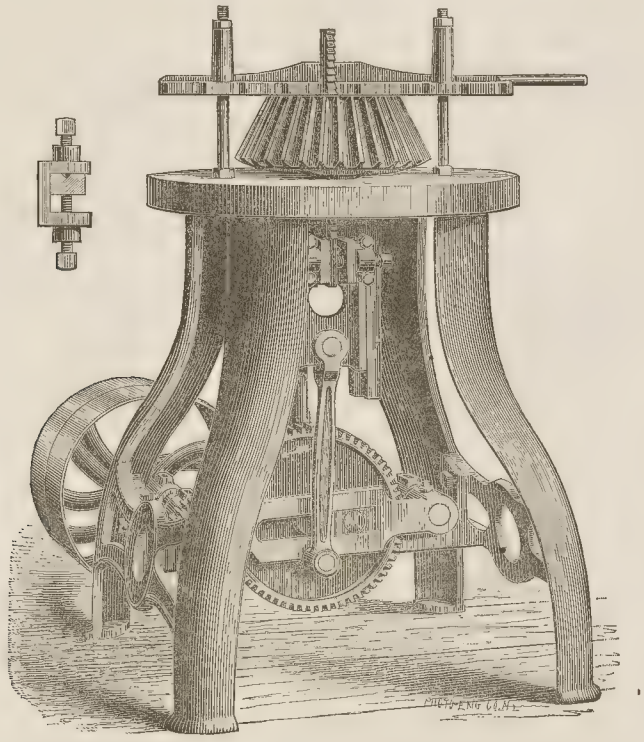


Fig. 272.

The cutting is done by the teeth on the point of a bar which resembles a developed milling-cutter. It can, of course, pass through a hole of quite small diameter.

§ 30.

D.—MILLING-MACHINES.

The term milling-machine may be applied generally to all metal-working tools operating with serrated rotary cutters. Where the cutter is very thin, the machine becomes a metal saw; where especially adapted for one operation, it is often known by a special name; but it still retains enough fundamental features to justify its classification with the typical machine.

The use of the milling-machine is attended with certain conspicuous advantages. These are the result of the revolving cutter, and the resulting elimination of spring in the tool. A great saving of time results from the continuous action of the cutters. There is no return or inactive stroke as in the reciprocating tools. The cutting-edges are very near to their points of support. Therefore exactness of dimensions may be insured and uniformity in duplication of irregular shapes. Again, the cutting-edges of the rotary cutter compel an outline of the work whose form accords with that of the cutter. Hence, if a pattern of cutter be fixed upon by a skilled mechanic, the reproduction of duplicate forms can be intrusted to a less skilled operative. Provided only the cutters are maintained in shape, and the work is properly chucked, the machine can be worked to stop-gauges without the repeated application of standards. For these reasons, the milling-machine in its various forms has become an essential in the manufacture of exact machinery. Operators become easily accustomed to working to a thousandth of an inch, and for fire-arm, electric, and sewing-machine work they have revolutionized the practice of earlier days.

One of the earliest forms of milling-machine for gun-work is illustrated by Figs. 273 and 274. In both the machines shown great improvements have been made over the original machine as made many years ago. The driving-spindle rises and falls in the uprights, controlled either by two screws geared (Fig. 273) or by one screw, equalized between the two boxes by a cross-head and stiff plungers (Fig. 274). Lost motion is prevented by the

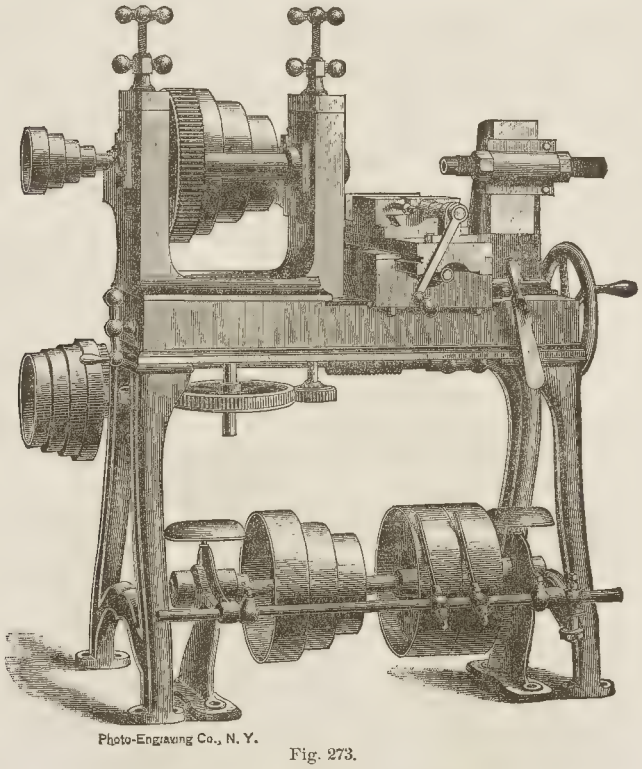


Photo-Engraving Co., N. Y.

Fig. 273.

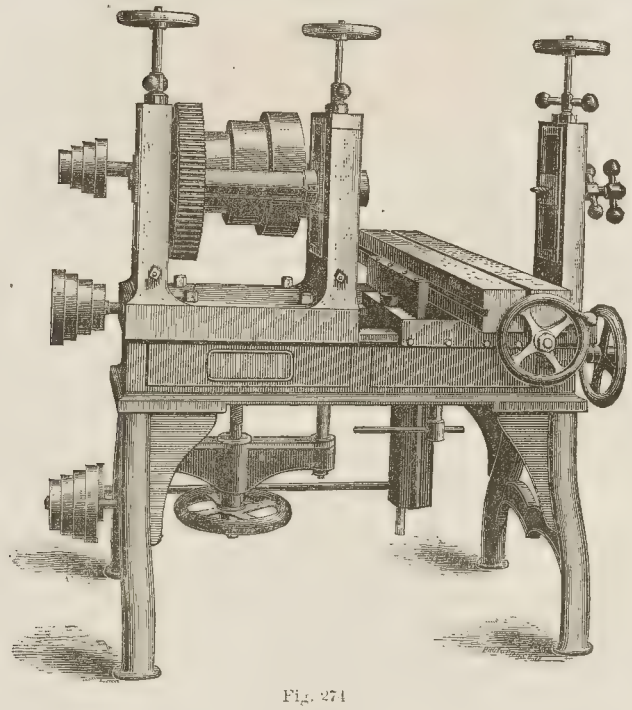


Fig. 274

jam-nuts on the top screws. The cutters are held on a mandrel, which fits into the end of the spindle, the outer end being borne by an adjustable center. This has a motion independent of that of the spindle, for convenience of taper work. The spindle is geared to a pulley-shaft, the latter shaft being adjustable laterally for various elevations of the spindle. There will be three or four grades on the cone-pulley. The piece to be operated upon is clamped in a vise or chucked to a table, which may have two motions. The motion along the axis of the cutter-mandrel is quite short, and is usually by hand only, for adjustment. The motion at right angles to this line and against the cutters is much longer and is automatic. A worm-shaft is driven by small cone-pulleys, and turns a worm-wheel,

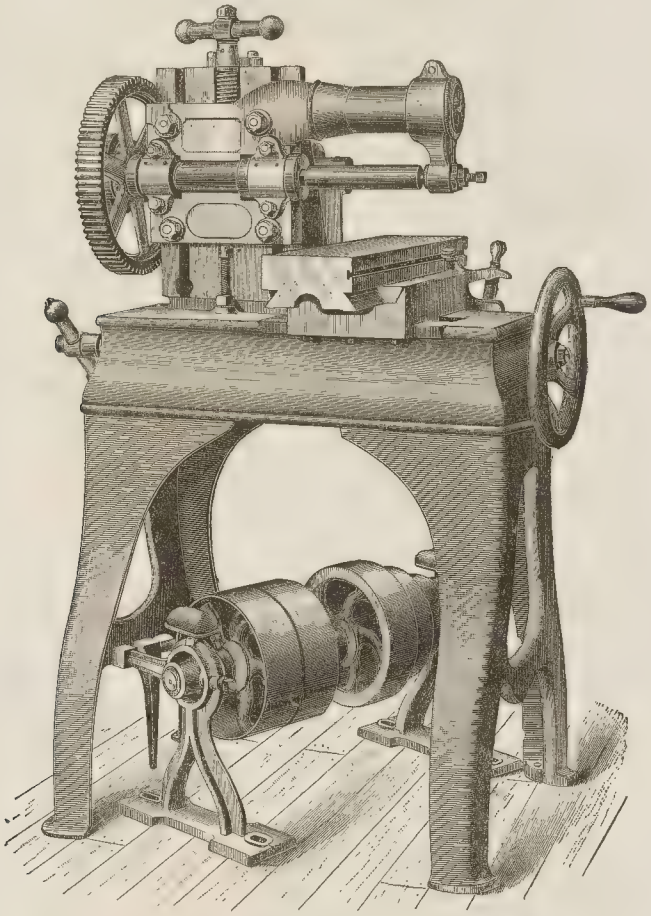


Fig. 275.

which meshes into a gear on the cross-feed screw. The worm-shaft is carried on a swivel-bearing at the head-stock, and the further bearing is connected to a pivoted lever. When this lever is latched up the worm turns the wheel. The release of the latch, either by an automatic stop or by hand, permits the worm to drop out of gear with the wheel, and stops the feed. The worm is made long so as to operate wherever the table may be in its longitudinal traverse.

Fig. 275 shows the construction of a machine, which is in some respects an improvement on the earlier forms. The spindle is held on a flat plate sliding in slots to which it may be clamped by bolts. It is adjusted by one large screw, and has a stop-screw below. The pulley-spindle swings on a yoke and is linked to the main spindle, rendering the lateral adjustment of its bearings automatic. The heavy slide insures parallelism of the main spindle at all times, which the unequal wear of the gears and screws of the earlier form was liable to vitiate. The feed-motions of the table are as before. Instead of a back-carrier stand, adjustable for mandrels of different lengths, an outside center support is attachable on an arm from the carrier. These will all move together and can be adjusted while the machine is in motion. A similar design is shown by Fig. 276. Milling-machines of this type are known as

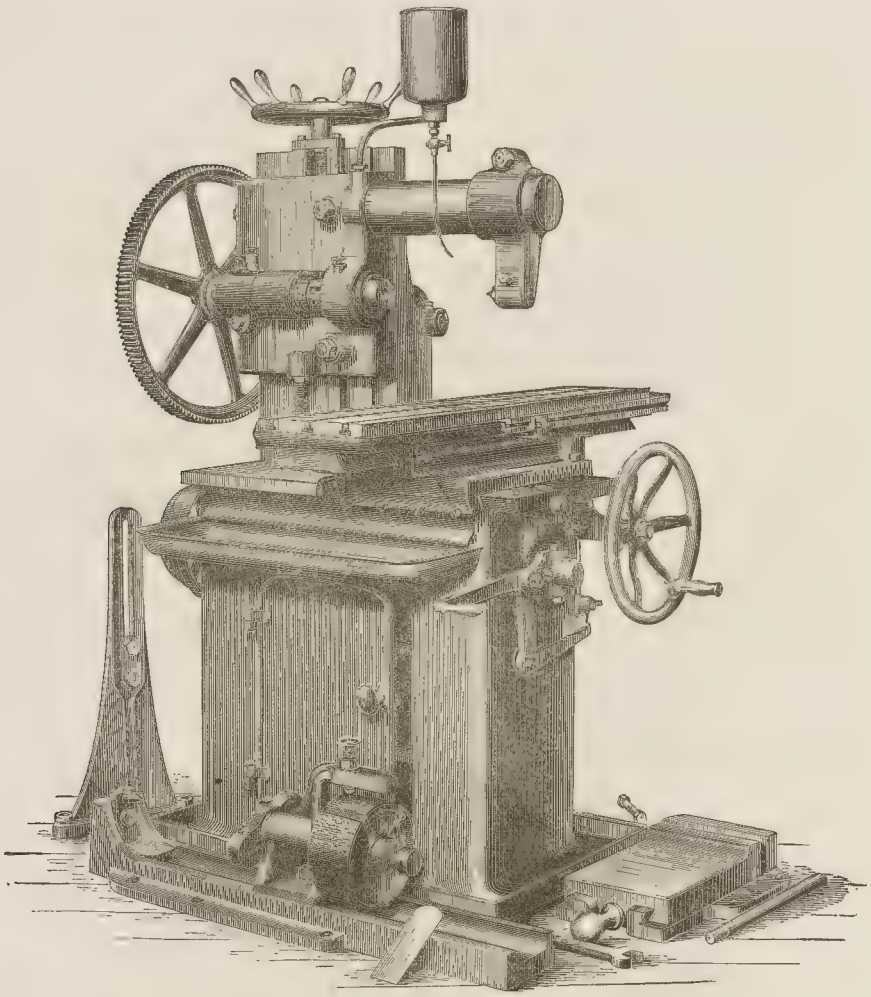


Fig. 276.

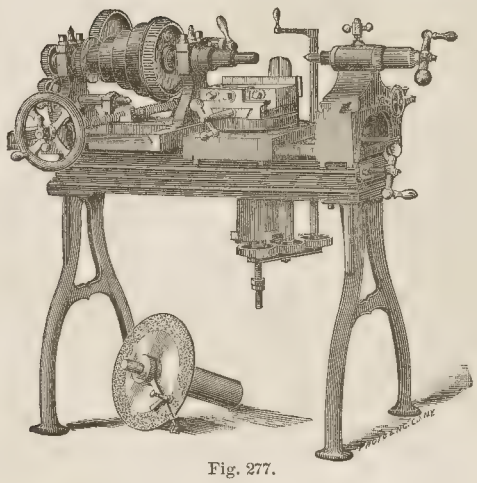


Fig. 277.

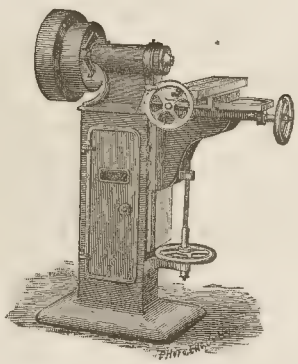


Fig. 278.

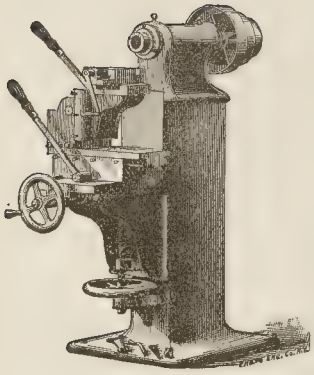


Fig. 279.

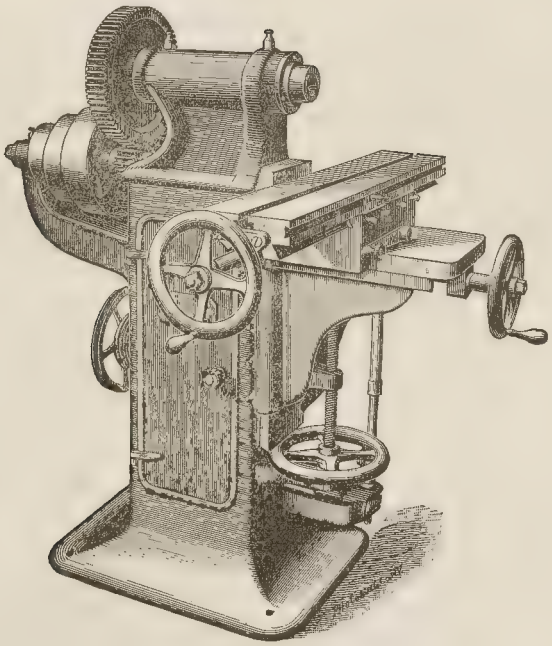


Fig. 280.

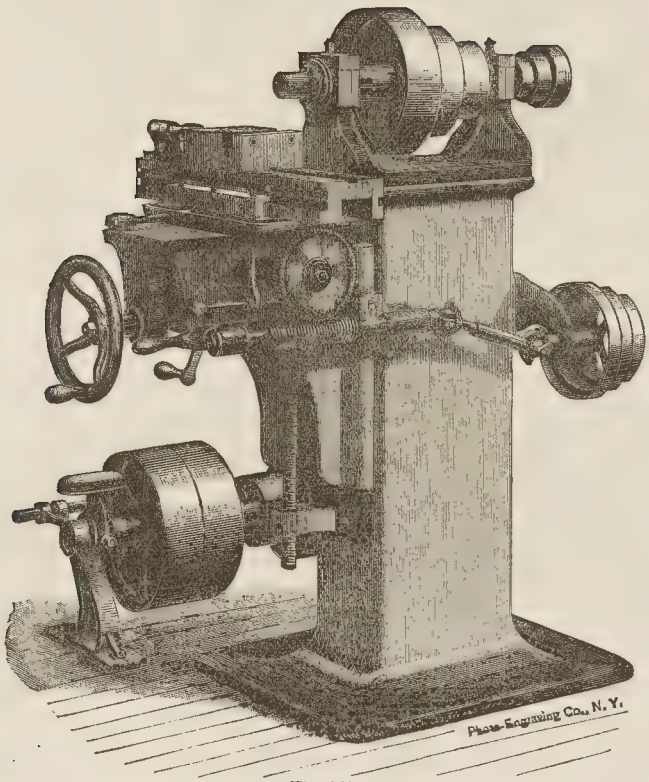


Fig. 281.

"plain" milling-machines. A milling-machine of a slightly different construction, but similar in principle, is shown by Fig. 277. The vise receives the vertical feed, and both the main and tail spindles have set-over motions. The tool illustrates the application of the lathe principle to milling purposes.

The second form of milling-machine is what is known as the "standard" machine. The working parts are borne upon a column or standard, which in many designs makes a convenient tool-closet for the attachments.

Figs. 278 and 279 illustrate types of the hand-machines. The spindle is driven directly by belt and the knee-table gives a vertical adjustment while the back-and-forth and right-and-left motions are given to the compound table. These are adapted for work with small cutters only, which turn at high speed, and the feeds are by screw or by rack and pinion by the levers.

Fig. 280 illustrates a larger design of standard miller with power-feed across the front. The screw on the hand-wheel shaft is turned by bevel-gear from the vertical telescopic shaft in front, which is driven from a worm-shaft at the base of the tool, as shown by Fig. 284.

Fig. 281 shows another way of producing the feed-motion by a long worm which may be disengaged by hand-lever in front. To compensate for rise and fall, the cone-pulleys are connected to the worm by two universal joints and a telescopic shaft. The double-joint also prevents the irregularity of feed from being as noticeable as it would be with but one. There is an automatic stop-motion for the feed, adjustable to any position. There is also a stop by jam-nuts upon the in-and-out hand traverse.

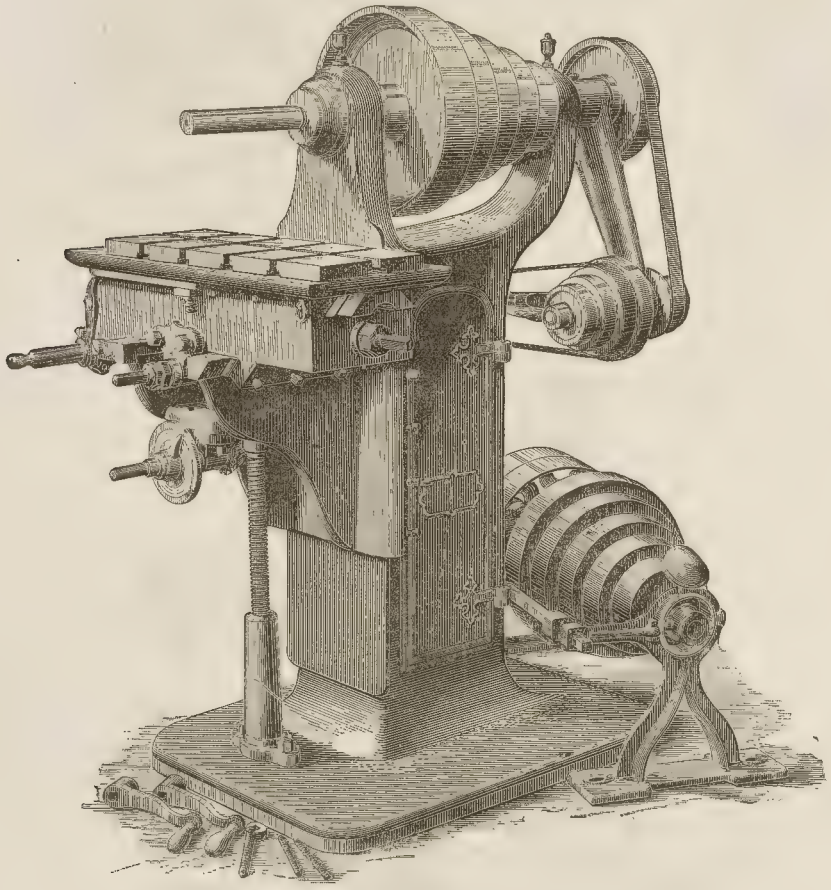


Fig. 282.

Fig. 282 shows the feed-worm driven by belts through a floating cone-pulley shaft. The stiff link swings around the box of the spindle, and an extensible link swings round the worm-shaft. The worm-shaft can thus be more accurately fitted to the adjustable table, and the tension of the driving-belt may be varied at will. The extensible link is forked and bears at both ends of the arbor. The spring latch at the left is acted upon by the adjustable stop under the oil-pan in front. The elevating-screw is turned by bevel-gear and is fitted with a graduated circle

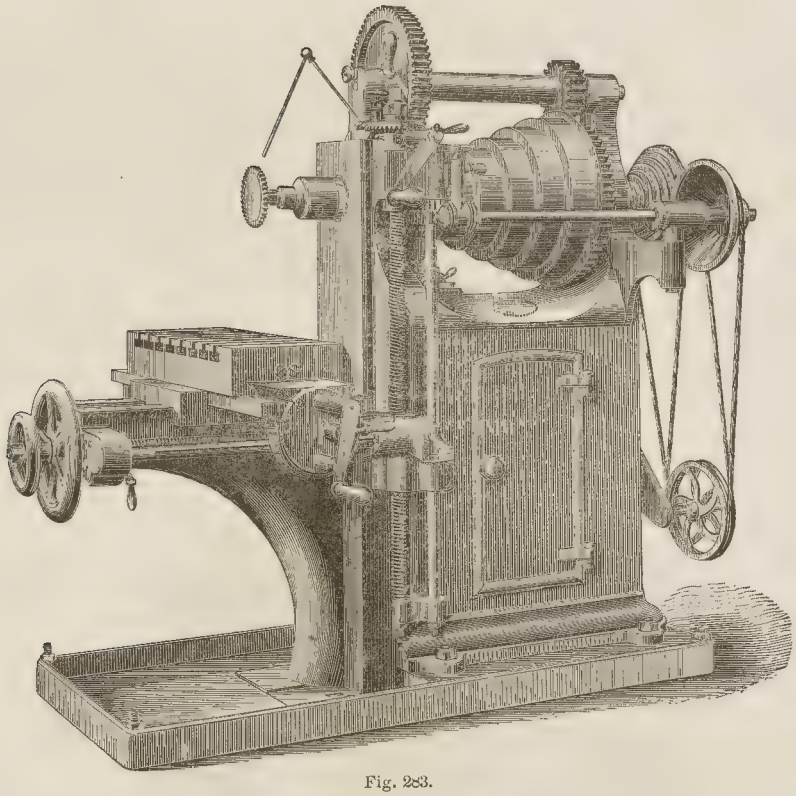


Fig. 283.

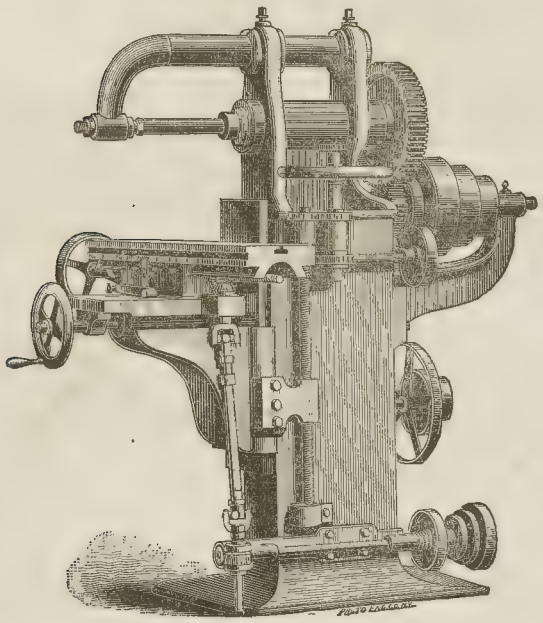


Fig. 284.

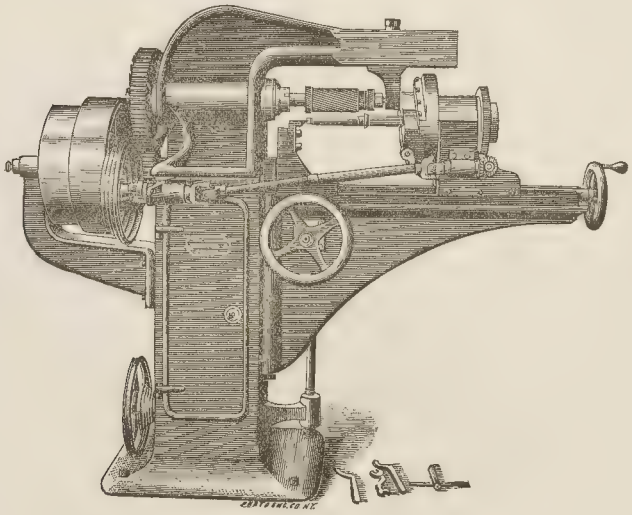


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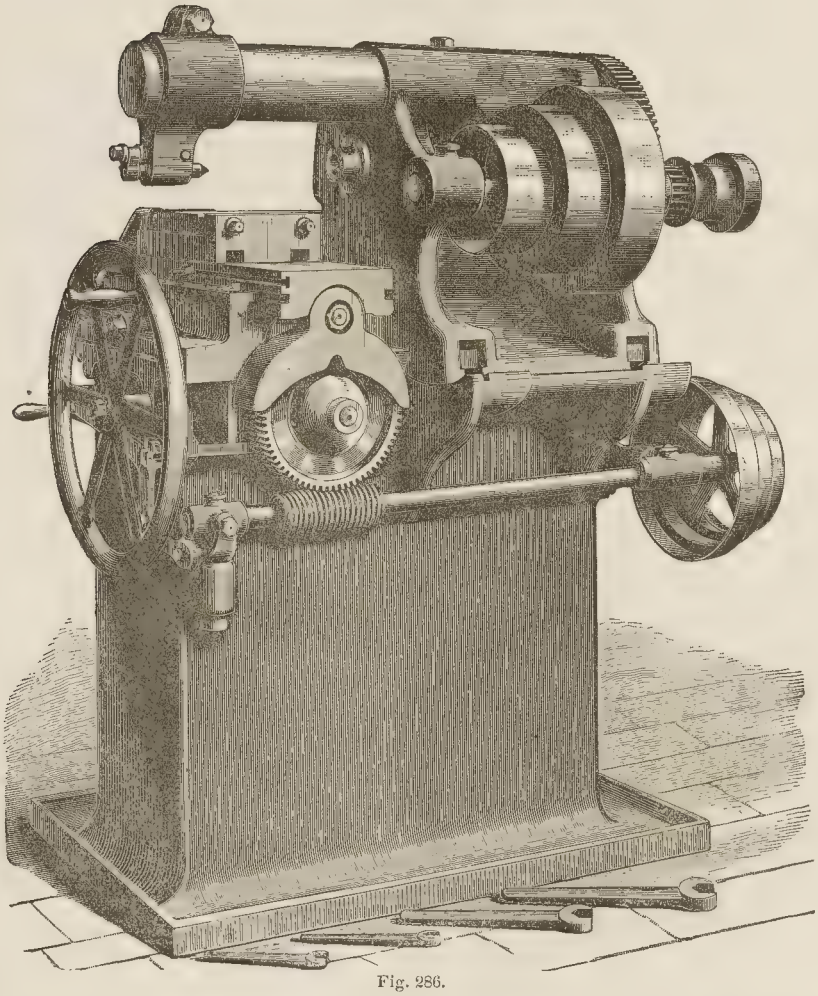


Fig. 286.

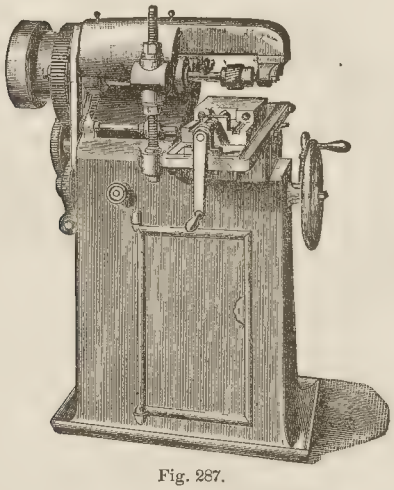


Fig. 287.

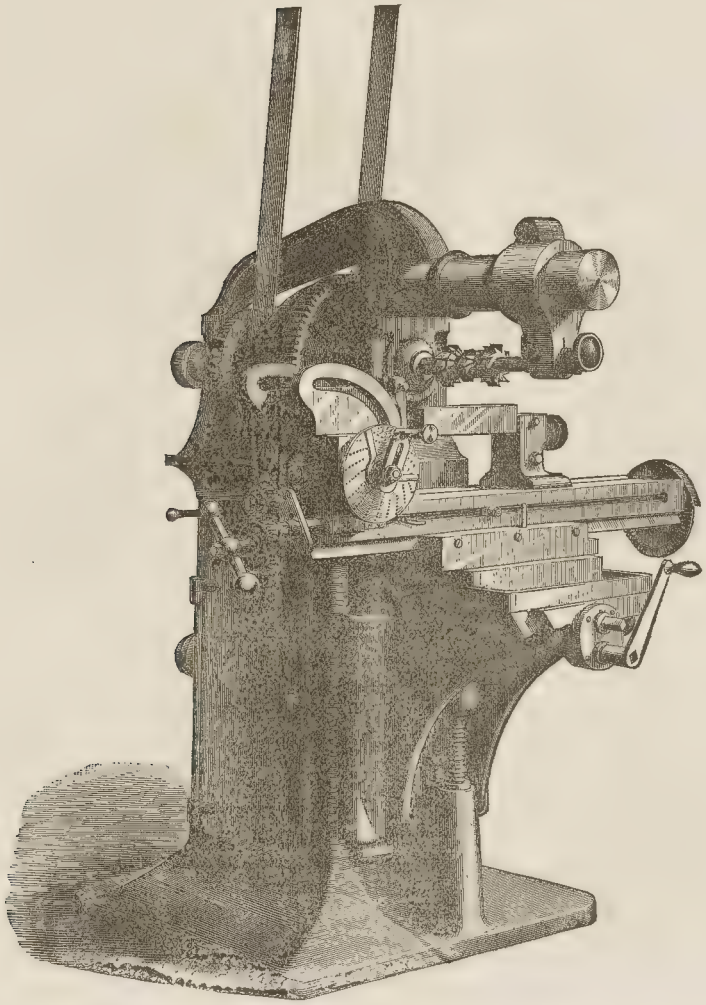


Fig. 288.

and index. By dividing the circle into 125 parts and using a screw of one-eighth of an inch pitch, the table may be raised by one-thousandth of an inch, or by one-half of that by ocular bisection of the graduations. The traverse in line with the spindle is by hand over 5 inches only.

Fig. 283 shows a type of back-geared milling-machine, with feed in all directions to the compound table. A twisted round belt transmits motion through a floating stud to a shaft with short worms, right and left. These may be engaged at will with a worm-wheel on a splined shaft which transmits motion by bevel-gears to a second splined shaft at the side of the knee-table. From this the motion is taken off by gears to the cross-feed screw at the end, and for the longitudinal feed. The feeds are disengaged by the short hand-levers shown near the screws. The knee-table is lifted by the screw at the side, the bearing being very long to resist twisting.

For larger tools it is necessary to have an outside center support for the mill-arbor. The strain of the cut might deflect the arbor and cause untruth in the work.

Fig. 284 illustrates an unusual way of accomplishing this result. The arm passes through rings and is set in place by screws, so as to uphold the mandrel by a center. The table has vertical and transverse hand- and power-feed by narrow belts to worm-shafts.

In Fig. 285 the arm for the center is cast with the head, and is not detachable, as is customary. The hanging arm bolts the center through a slot, by which arbors of different lengths may be accommodated. The cut illustrates a tool of this class applied for the special duty of milling out the profile of a carriage-axle at one operation. The square of the axle receives feed-motion by a tangent-screw to the special-holder vise. A type of solid arm, with adjustment vertically, is shown by Figs. 286 and 287. In both figures the compound table has no vertical adjustment for differing thicknesses. This gives steadiness to the table and for its motions, and simplifies the feed connections. In Fig. 286 the casting which carries the arm and spindle is fitted to a concave arc on the standard. The center of the two arcs is the center of the cone-pulley shaft. The movable casting slides on tenons in the arc of the standard, as governed by a screw at the rear, moving tangent to the arc. By this means a vertical adjustment of 6 inches is possible, without interfering with the driving-belt. In Fig. 287 the arm and spindle-casting is hinged at the right, and a pillar-screw and jam-nuts secure the swinging arm in the proper adjustment. The motion takes place around the center of the gear-axis as before.

The most familiar types of the universal standard milling-machine are shown by Figs. 288 and 290. They embody the highest refinements of construction for exactness and finish, many of which are applied in the smaller machines as well, or may be omitted or replaced in designs of less elaboration. In Fig. 289, which shows part of

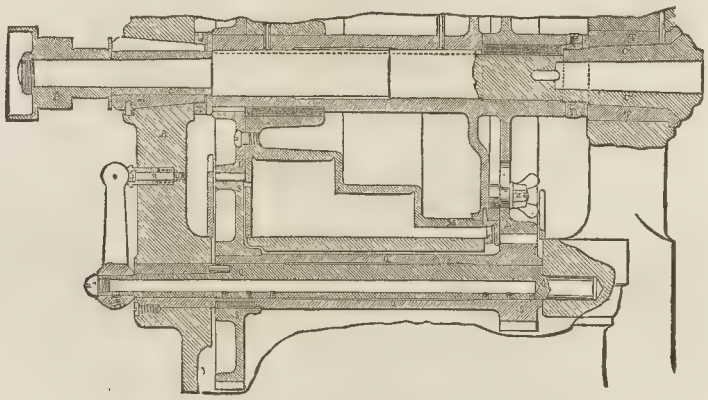


Fig. 289.

the detail of the head of the machine, the spindle C C′ is of hammered steel, hardened and turning in hardened boxes. The spindle is ground at front of box to tangents to the Schiele curve to receive the thrust on the end. A long taper socket is made in the spindle to receive the ends of mandrels. The front box is solid, forced into the supporting casting. A capstan-nut with set-screws on the spindle can take up any lost motion from wear, by drawing inward the conical bearing. The rear box is split, and wear is taken up by a capstan-nut which compresses the box upon the journal as it draws inward the cone of the outside of the box into the casting. Back-gearing is applied below the main spindle, a spring catch holding the engaging-arm in place. The outside center support is bolted to the top of the uprights of the spindle-bearings, and the center clasps the finished arm by a bolt, which closes the split. The dead-center has also a fine adjustment by a milled head on a screw, this having also a split clamp. The vertical and back and forth feeds are by hand. The transverse feed is from the cone-pulleys on the spindle to a complementary nest at the side of the standard. By two universal joints and a telescopic shaft motion is transmitted through a jaw-clutch to the bevel-wheel on the end of the feed-screw. This jaw-clutch can be disengaged by an adjustable stop on the table. It has all the usual and necessary attachments, to be alluded to in the sequel.

Fig. 290 shows a universal standard milling-machine differing from the preceding in several points. The bearings for the spindle are cylindrical, and the thrust of the mills is borne by composition washers on a step-screw at the tail. The journals are of bronze split at one point, and wear is taken up by capstan nuts on each side of the castings of the standard. The arm for outside center has a long cylindrical fit in the cap casting, with about

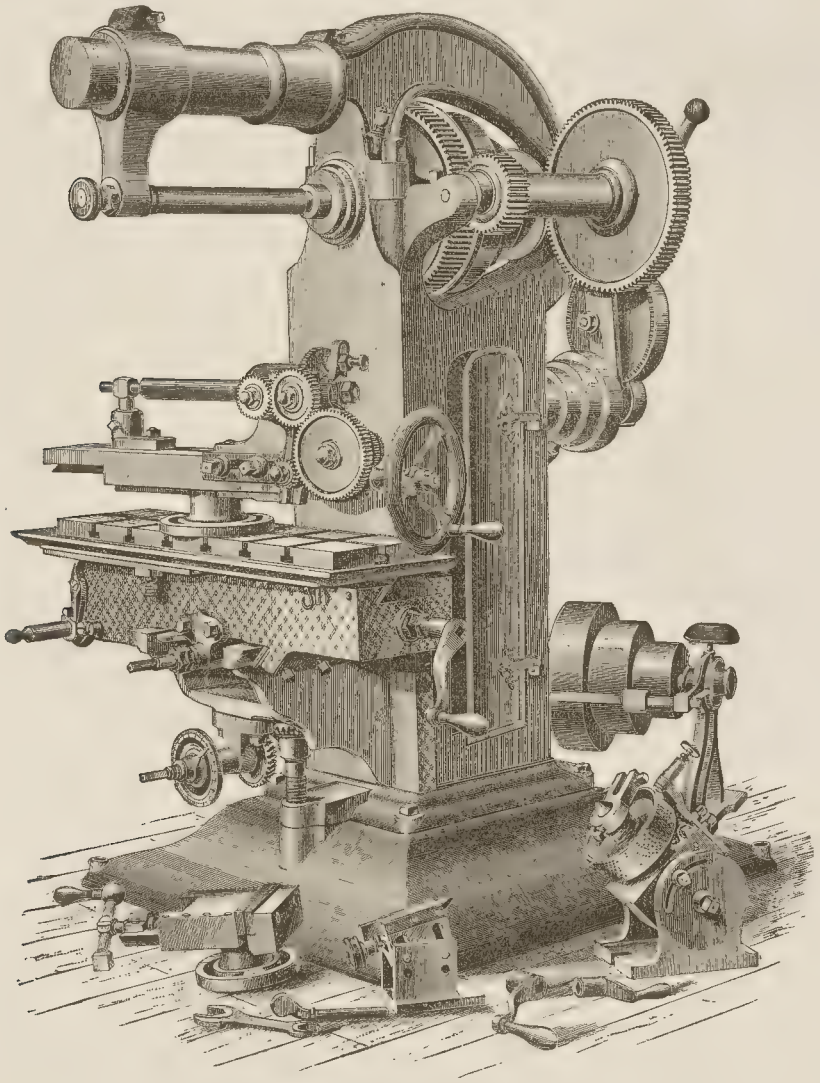


Fig. 290.

1 inch of thread. When screwed home to refusal the split is tightened to prevent the arm from jarring itself loose. The back-gears are at the side, and the feed-shaft is driven by shielded gear and belt through a floating cone-pulley shaft linked to driver and follower. Wear in the feed-screws can be taken up by double nuts. The same fine graduated motion to the table is obtained as in Fig. 282. The main spindle is hollow for convenience of driving out mandrels. In these tools of this class the workmanship is of the best and most accurate. The surfaces are scraped with the greatest care and regard for truth, and so accurately is the work fitted to gauges that in the T-slots in the tables a tenon gauge may be pressed in by hand, but must not fall in easily. From this exactitude in the machine it follows that its work can be correspondingly exact. Units which were formerly thought so small as to be rather in the field of the physicist are now of frequent occurrence in our workshops.

Fully to entitle these milling-machines to the term "universal" certain attachments are required to go with them. These will bolt to the top of the table in the T-slots, of which there will probably be one longitudinal and four or six transverse. The first of these will be a vise, which can swivel to any horizontal angle (Figs. 291 and

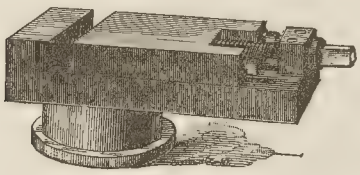


Fig. 291.

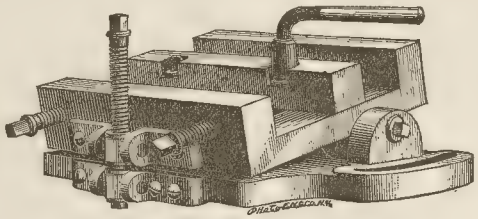


Fig. 292.

292), and one design permits vertical swiveling also. Any form of holder may be designed for any especial shape or process.

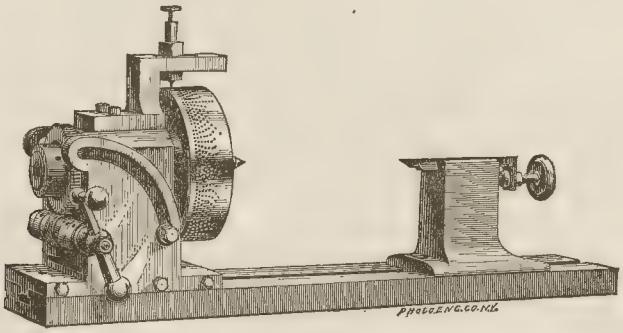


Fig. 293.

The second attachment is a universal head, which can also be used as a simple pair of centers. Fig. 293 illustrates a usual form. The head center is hollow, for rods of any length, and is fitted with a screw in front to hold a chuck or dog-jaw. The spindle may be revolved through any number of degrees by the tangent gearing, the divided cylinder in front serving as index and stop-gear. The whole center has a motion around the axis of the worm, by which an elevation may be given to it for working out tapers with a straight parallel mill. The stationary center has a short pin adjustment when clamped in place.

Fig. 294 shows a similar head with patent back center. The upright is faced on the inside, and fits the inner

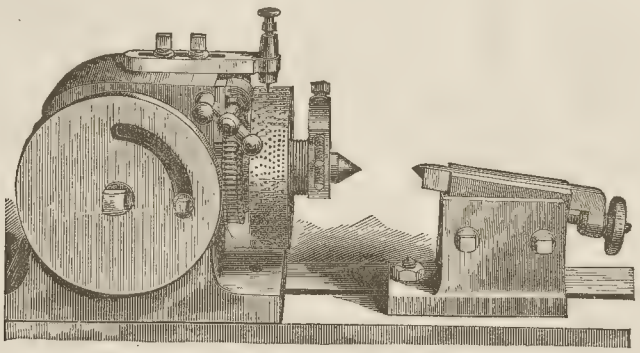


Photo-Engraving Co., N. Y.

Fig. 294.

block, which carries the spindle proper. The two parts bolt together by bolts through the curved slots of the inner block. The center is therefore capable of elevation and depression, but can also be set at an angle, so that tapered work can be finished without danger of throwing the point out of the center line of the countersink and wearing both surfaces unduly. These heads will permit gear-cutting, both spur and bevel. The index-dial will divide in an average size of head all numbers to 25, all even numbers to 50, and several others up to 120. One large head has been made by these builders which will divide a circle into eighteen thousand parts with the highest limit of accuracy, and it will divide it even into fifty-four thousand parts. The worm-wheel is made with sharp V-threads,

and contains 180 teeth. The wheel is in two parts, and no matter how the two disks may be screwed together any two half-teeth form one without perceptible error. A graduated disk receives a spring pawl, by which exact record can be kept of the turns of the worm. There are arrangements to take up wear longitudinally by check-capstan nuts and vertically by hollow capstan-nuts on the block with through clamp-nuts.

The other attachment for the milling-machine table is a spiral cutter. While the work is fed longitudinally by a screw against the cutter, it receives also a motion around its own axis (Fig. 295). This second motion is derived from a worm on the screw by a train of change-wheels, and spirals may be originated and cut with pitches varying between 2 and 72 inches. The spiral may be cut upon a cone as well as upon a cylinder by a special device.

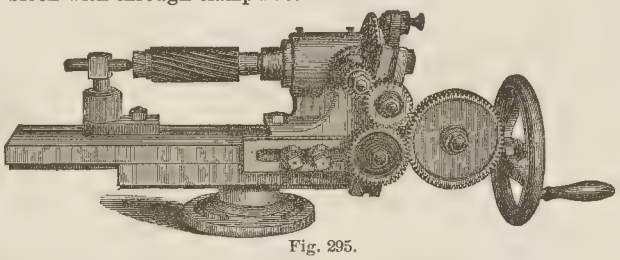


Fig. 295.

Of course for any special manufacture special appliances may supplement these standard attachments. With such devices the application of the machine to all kinds of work becomes most simple. Its use is extending, and is having a most important bearing upon exact manufacture.

§ 31.

SPECIAL FORMS.

For the use of drop-forging apparatus it is necessary that the steel dies be carved out to the exact shape desired. This manufacture of dies is called "die-sinking", and has given rise to a special form of milling-machine. Fig. 296

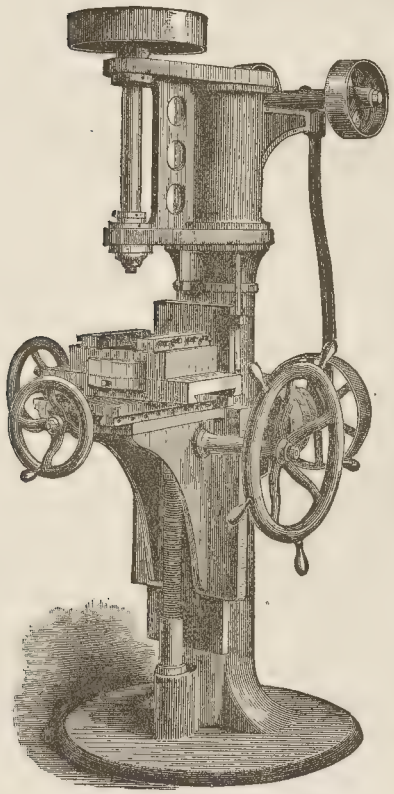


Fig. 296.

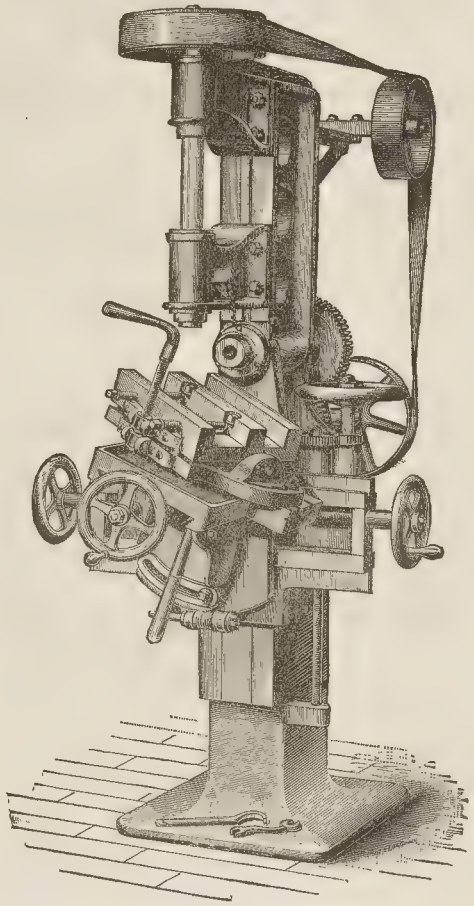


Fig. 297.

illustrates a type. The cutter is vertical, driven by a belt over guide-pulleys. The mill usually cuts on both face and side. The vise has compound motion by hand, and the knee-table can be raised and lowered. There are special devices for taking up thrust and lost motion at the bearings. Very often the motions to the table and vise are given by levers.

Fig. 297 shows a machine with both horizontal and vertical spindles and universal motion to the vise. A saddle has two motions in a vertical plane, and a swivel table, controllable by a worm, holds the slide which receives the vise. All the motions are controlled by hand-wheels within convenient reach of the operator. Such a machine, of course, can be used for any of the small work of miscellaneous milling.

For edge-milling or profiling the irregular shapes of several classes of manufacture the type of machine shown in Fig. 298 is approved. The pieces to be dressed are clamped to the table, which receives a backward and forward

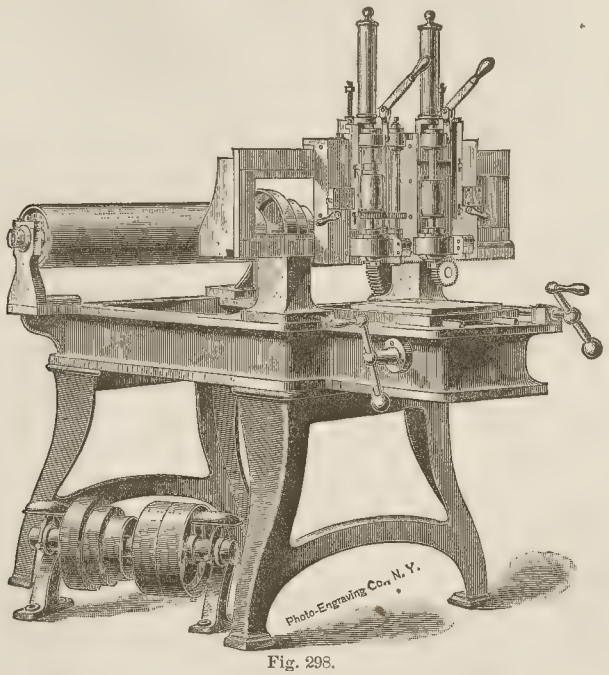


Fig. 298.

feed by rack and pinion from the ball-handle. The mills are carried in the vertical spindles, which are borne on a saddle, which receives transverse motion by a pinion on its under side through the ball-handle on the right. A former is secured to the table, and the operator controls his two feeds by that. The spindles have vertical motion by the hand-levers between adjustable stops for depth, and are driven from the long drum at the rear. This machine has a patent device for cutting formers without reversing the fixtures. The guiding-pin may be driven by gear from one spindle, and the cutter and pin exchange places, while the model is secured to the place which the work is to occupy in the future. The cutter on the guide-pin cuts the forming pattern in the exact position it will retain in use. The gearing and rack are made double, so as to be adjustable to prevent any back-lash in the feeds. This is essential for accuracy of irregular work, and especially in turning corners. Such a machine can also be used as a jigging and die-sinking machine. There may also be three spindles. A rotary cutter has been mounted upon an arbor transverse and parallel to a planer bed, and is used to mill out the flats of locomotive-rods. It is then known as a slabbing-machine, and will take a 4-inch cutter the full width of the rod. For cast iron a larger cutter may be used with advantage. Where, however, heavy work is to be done, the use of inserted cutters is expedient. The work done will then be proportional to the number of cutters, as compared with reciprocating tools.

An example of the economic application of this principle is shown by Figs. 299 and 300. The tool (Fig. 299) is designed to face off the ends of bridge and other girders to exact dimensions. The work is bolted to a stationary table, and the mill traverses in front of it. Several may be secured at once, and each is held independently by a set-screw through the clamp. The mill consists of a solid wrought-iron disk of tough and homogeneous metal. It is 2 inches thick and weighs 400 pounds. Eighty-four teeth are inserted in the rim, on edge and face alternately, and since the disk is 28 inches in diameter the alternate system permits a tooth upon every inch of circumference. The teeth are of steel, $1\frac{1}{8}$ inches face by $\frac{7}{8}$ of an inch thick, and are fitted in milled grooves. The milling-disk is

driven by a large steel worm on a splined shaft, by which a vertical adjustment of the slide is possible. The whole head is fed along by a screw either by hand or by power, through a worm-gear from cone-pulleys, and the feed can

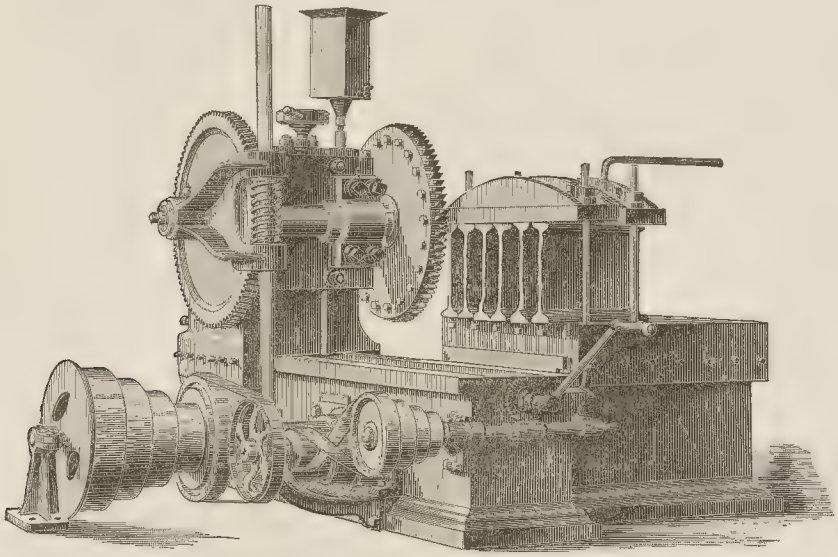


Fig. 299.

be varied from $\frac{1}{8}$ of an inch to 1 inch per revolution. Such a machine can square and finish six 15-inch beams per hour, allowing $\frac{1}{2}$ inch of metal to be cut from each end. If less is taken off the feed may be more rapid. In Fig.

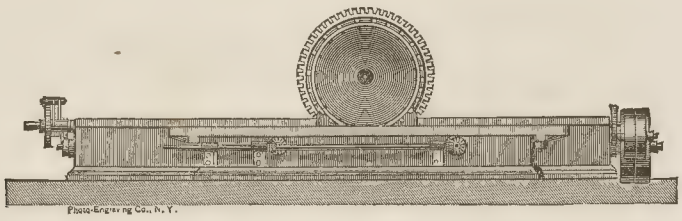


Fig. 300.

300 the cutters are twenty-eight in number, on a 25-inch plate wheel, which is banded with wrought iron. The wheel is driven as in the other tool by worm-gear, and the whole head is made to travel by an automatic variable feed.

§ 32.

GEAR-CUTTERS.

Any of the universal millers can be used as gear-cutters by means of a universal head, with worm-wheel and index. They can usually cut both spurs and bevels. There are certain tools, however, which are built for that especial purpose, and may properly be discussed by themselves.

Fig. 301 illustrates the type which has been in very general use. The blank from which the spaces between the teeth are to be cut is held firmly upon the end of a vertical arbor. Upon this arbor is secured the index-plate, with its stop-pin, adjustable legs, and clamp. The cutter is borne upon a slide which has a power-feed across the face of the blank, and the whole upright has adjustment for different diameters of blank. To compensate for the motion of the cutter-arbor the belt passes over a hinged binder-frame overhead, which is weighted to maintain a constant tension on the belt.

Fig. 302 illustrates a standard type of machine. The cutter-carriage is swung from a fulcrum on the standard, and may be set to cut bevels of any angle. The cutter is fed automatically across the face of the blank, and has a stop-gear. The mandrel for the blank may be adjusted for different radii of wheels. The wheels are divided by a worm-wheel.

To increase the adaptability of the milling-machine for bevel-wheels such machines as Figs. 303 and 304 have been produced. In Fig. 303 the index-plate is attached to the bottom of a hollow spindle, which swivels around a

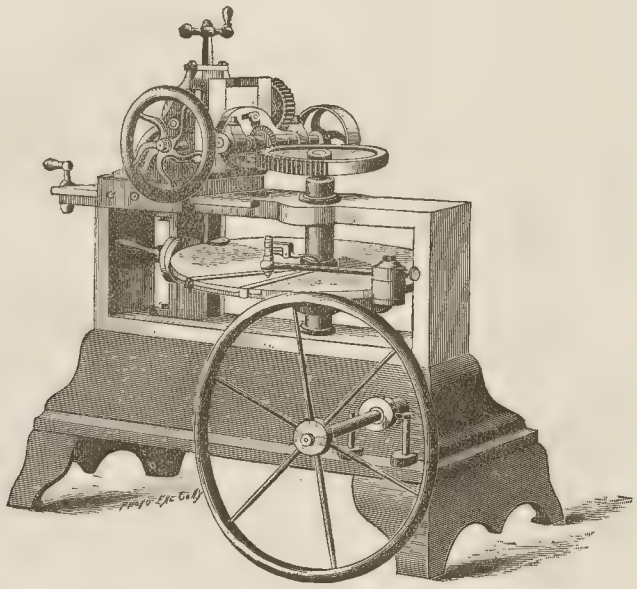


Fig. 301.

center on a vertical slide. The spindle can take a vise or centers or any attachment, and can be set at any angle between 0° and 180°. The vertical slide has a perpendicular traverse of 2 inches and a horizontal adjustment between stops for different diameters. The machine can therefore cut spurs and bevels and worm-teeth. The cone-spindle has a horizontal movement by hand-lever limited between check-nuts.

In Fig. 304 the mill-arbor is driven by bevel-gear from the splined shaft to avoid the necessity for the binder-frame. The vertical spindle has the same motions and adjustments as in the previous machine. As this is designed for general work also, the vertical spindle is arranged to clamp so as to relieve the index-plate from strain, as in the preceding type.

Fig. 305 illustrates a machine specially adapted for racks. The cutter is borne on a horizontal slide driven by gears from the cone-pulley, and more than one cutter may be used at once. The cutters are fed forward by power automatically, and the pitch for the rack is given by a spring stop into the teeth of a change-wheel. The train can be so arranged relative to the pitch of the traverse screw as to have the two pitches commensurable, and the pin should pass over always the same number of teeth.

In the best practice for larger wheel-work the drilled index-plate is replaced by a large worm-wheel, and motion to the worm is transmitted from a crank by a train of change-wheels, as in Fig. 302. The crank is arranged to lock with a spring latch or by a jaw of some sort, so that any number of entire revolutions of the crank may be so multiplied or divided as to effect any subdivision of the circumference of the worm-wheel. By this means the errors of fractional subdivisions are avoided, and also possible inaccuracies from the division or wear of the index plate. Moreover, when the worm-wheel is large, any errors in it are reduced in cutting-wheels of smaller diameter than itself, which will always be most numerous. The only source of error is from the danger of making the wrong number of turns of the crank-shaft. The combinations and numbers of turns can all be worked out and tabulated in advance.

The most advanced types of gear-cutters are those which are automatic. They are made by several of the best builders, and after adjustment of the blank and the combinations they will operate without supervision from the attendant. It is therefore possible to keep four machines full and earning their own interest, with the cost of the labor of but one operator to be divided among the four. Beside, the automatic machine is likely to work more rapidly than a similar machine worked in part by hand. There is a general resemblance in the mechanical devices for securing automatism, though the machines differ widely in outward form and appearance and differ in their adaptedness for large and small work.

A Providence machine for wheels up to 18 inches diameter, with 3-inch face, is shown by Fig. 306. It will cut wheels of any angle by the sector adjustment of the cutter-slide, which carries a graduated arc and index. The cutter-mandrel is driven by belt, with idle-pulley, for equality of tension. The wheel is secured on the horizontal

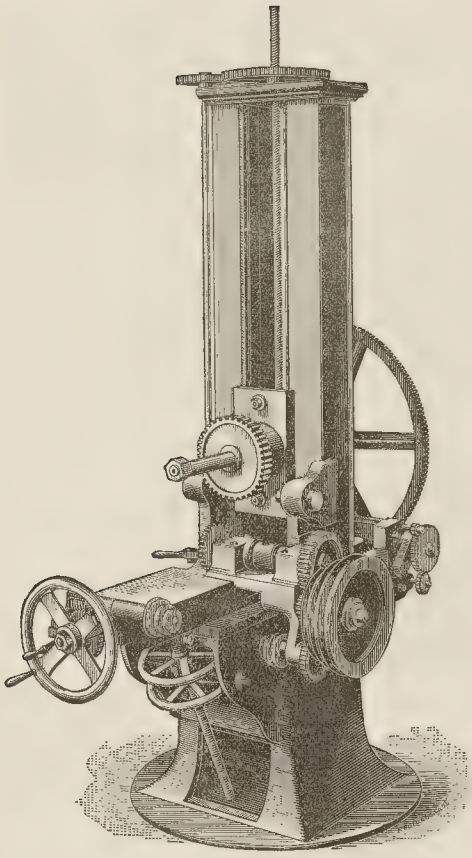


Fig. 302.

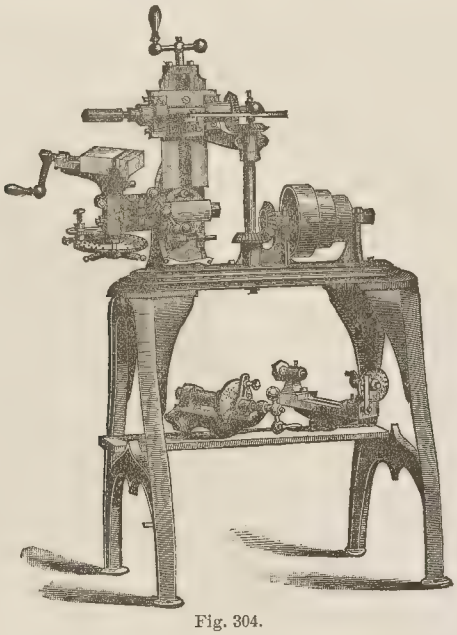


Fig. 304.

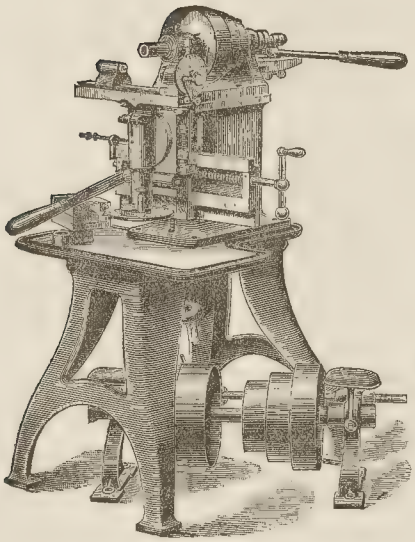


Fig. 303.

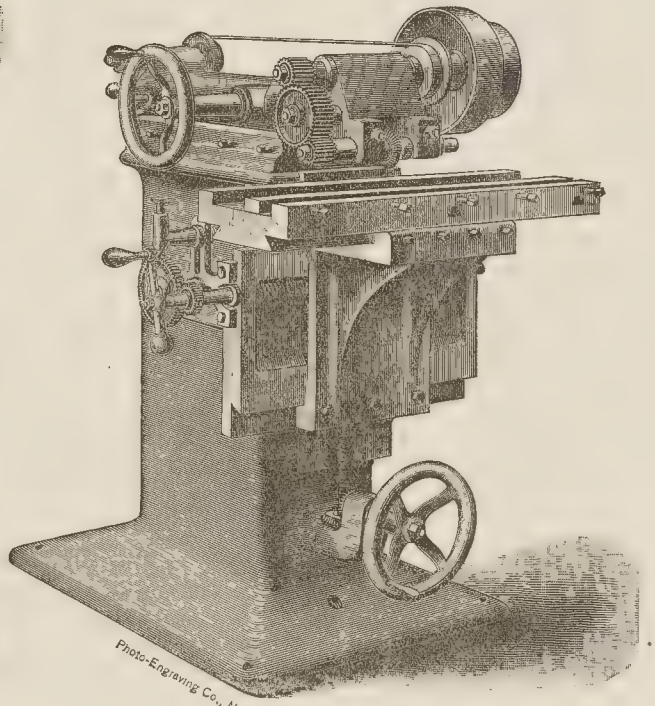


Fig. 305.

arbor, and the latter is adjusted by a scale graduated to thousandths of an inch for exactly the proper depth of tooth. The cutter-slide is fed forward by a screw at the proper speed, cutting through across the face, and when the cut is made the slide returns at quick speed. This is effected by a clutch between bevel-gears on opposite sides of the driving-shaft, and of different diameters. The shifting device is prevented from stalling by wedge-points, one on the clutch-lever and one on a movable stud pressed forward by a spring. As the two wedges cannot hold by their sharp edges, the compressed spring will certainly throw the clutch to one side or the other. To give the proper rotation to the blank, that the next cut may be properly made, the mandrel carries a worm-wheel. The worm which drives it is borne upon a splined vertical shaft, driven from below by change-wheels. The spline permits adjustment for wheels of differing diameters, and the worm is turned and locked by a special device. When the cutter-slide has retreated it engages a clutch, which puts a train in motion, turning the worm. On this clutch-shaft are two wheels, side by side, with their faces plain, except a notch in each. One wheel is fast on the shaft; the other is loose, and is driven in the direction opposite to that of its mate by internal gearing from an idle shaft. It is obvious that a detent can only fall into the notch of either wheel when that of each shall coincide under it. This detent can be so shaped as to lock both wheels and to disengage the clutch which is driving them. Since the wheels are driven in opposite directions, it is simply necessary so to arrange a train of change-wheels that the two notches shall coincide only when the proper number of revolutions of the worm shall have been made. When the shaft has gone round the standard number of times, the notches coincide, the detent falls into them and locks the worm-wheel and blank, and disengages the driving-gear. The detent is loosened by the return of the cutter-slide.

In one of the Philadelphia designs the worm-shaft is driven by a train of change-gears, which must change the speed of the driving-arbor by proper alteration of the six revolutions which the latter always makes when engaged by the return of the cutter-slide. This series of six revolutions is secured by the action of dogs upon two equal wheels with different numbers of teeth.

Fig. 307 shows a special automatic pair of machines, one for spur-wheels and the other for bevel-wheels of small dimensions for light machinery.

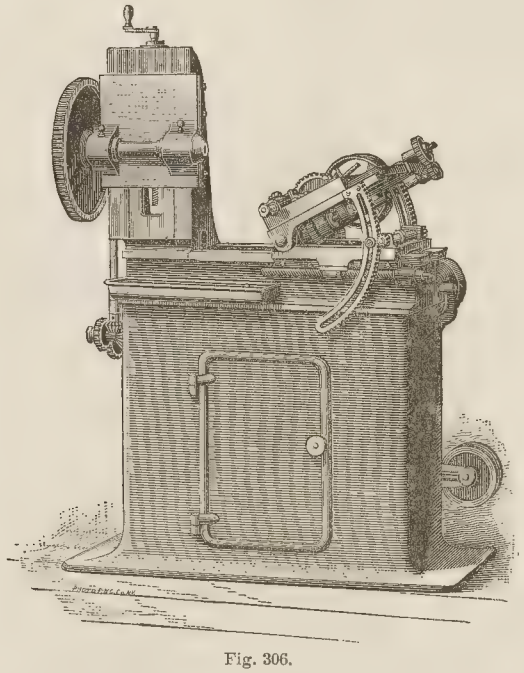


Fig. 306.

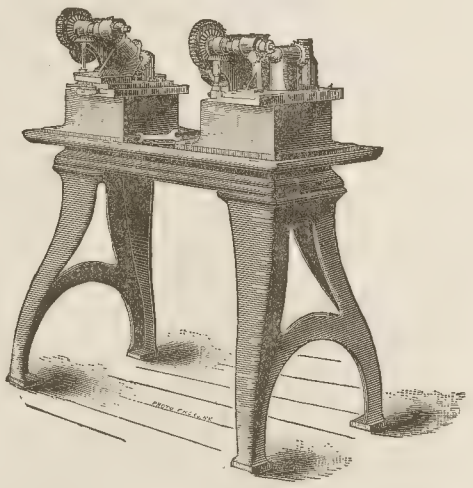


Fig. 307.

Figs. 308 and 309 *a* and *b* illustrate a large automatic machine for bevel- and spur-wheels up to 4½ feet in diameter and of 12 inches face. It will divide the circumference of wheels containing from ten up to three hundred and sixty teeth. The cutter is borne upon a horizontal slide, with variable traverse and return motion. It is driven by bevel-gear from the cone of belt-pulleys, the belt passing over a counter-weighted tightener-frame. The feeding and dividing motions are obtained from the central vertical shaft. By supporting the outer end of the mandrel for the blanks a large number of thin wheels may be cut at one cross-traverse.

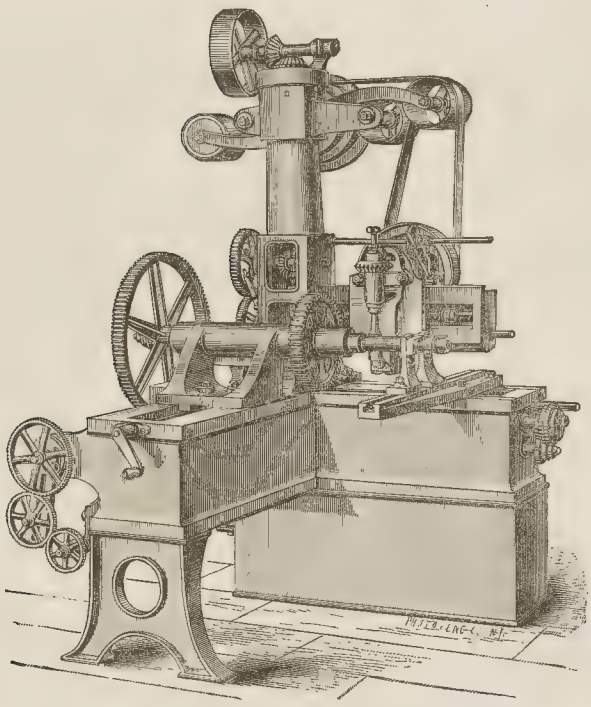


Fig. 308.

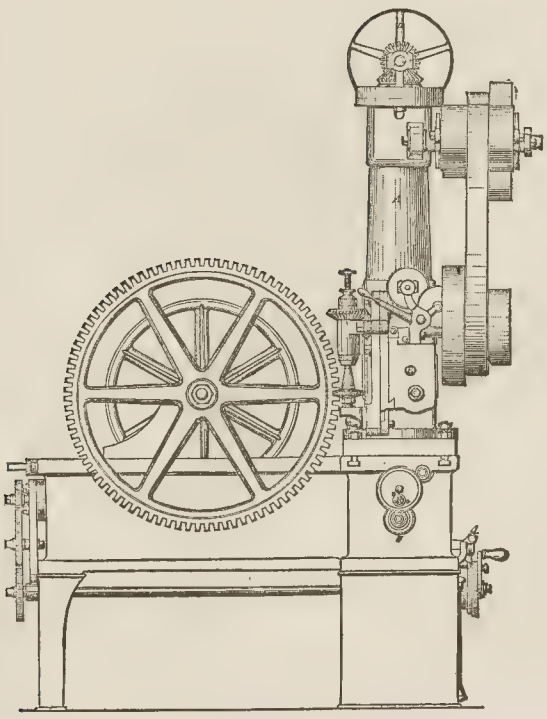


Fig. 309 *a*.

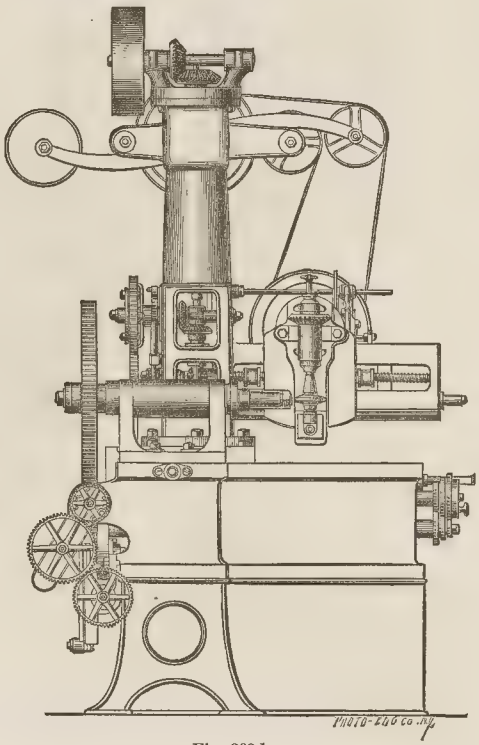


Fig. 309 *b*.

For the rotating cutters for these machines a very general type of patent cutter is shown by Fig. 310. Such cutters are so constructed that they can be sharpened by grinding upon the flat front face without spoiling the profiles of the side edges. The relief necessary for the top of the cutting-face obliges the profile to retreat toward the center. If only the top retreated, each successive grinding would make the space cut in the blank more and more shallow. To avoid this, each cutter is turned in a relieving lathe. The forming-tool receives a special forward motion from the tip to the root of each cutting-tooth as the mill being shaped revolves on a mandrel. This forward motion is imparted by a cam under the former-slide, which revolves once for each cutting-tooth of the mill (Fig. 311). To make the forming-tool, the true profile is worked out and a male chisel is made from it. By this male tool a female tool is planed out, and this latter is used to turn the spiral profiles of the mill itself. By distributing the numbers of teeth in each circular pitch among eight cutters the errors from inexact profile are made quite small.

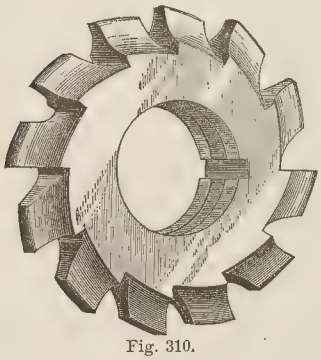


Fig. 310.

In another system (Pratt & Whitney, Hartford, Connecticut) an especial tool is used for producing an exact epicycloidal profile in the templet from which the mill is to be shaped. Fig. 312 shows a side view, and Fig. 313 gives a view in oblique plan. By this means is eliminated the variableness of profile of hand-made equivalents. From this templet, mechanically exact, as a former, the profile of the mill proper is reproduced. If the edge of a templet,

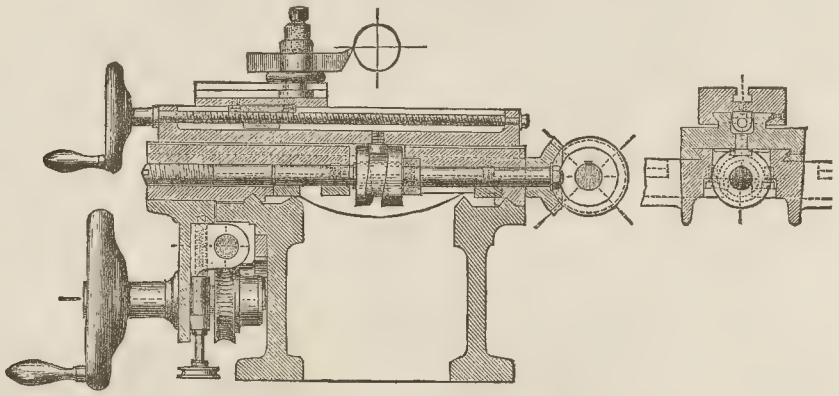


Fig. 311.

T T (Fig. 314), has been shaped by a cutter traveling on a true epicycloidal curve, a roller, P, running along the profile of T T, will make another cutter, N, on the axis of P, reproduce a profile, R S, which has a constant

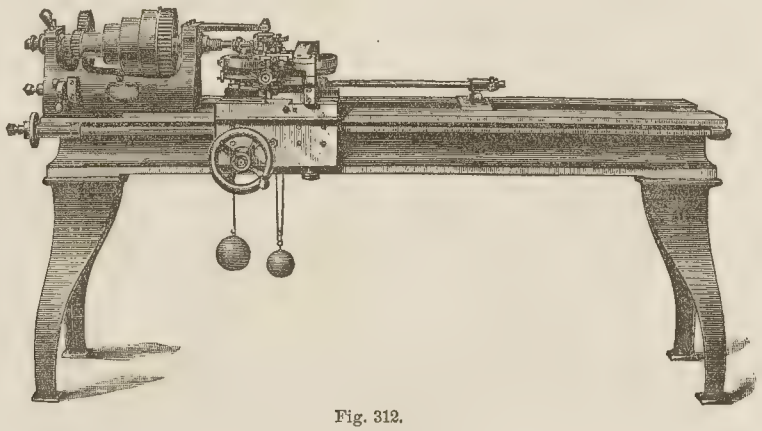


Fig. 312.

normal distance from T T. The reproduction of such curves for cutters is done by turning the cutter nearly to the required form and notching it for the cutting-edges. It is then put upon the pantographic cutter engine (Fig. 315), by which the exact profiles are produced for any other pitch by reduction with a simple device. The pantographic

engine will reproduce any type of tooth profile other than the epicycloidal, if supplied with the corresponding templets. This method gives exceedingly satisfactory results. It is open to the theoretical objection that even a roller of the same size as the original milling-cutter will not retrace completely the cycloidal path in which the

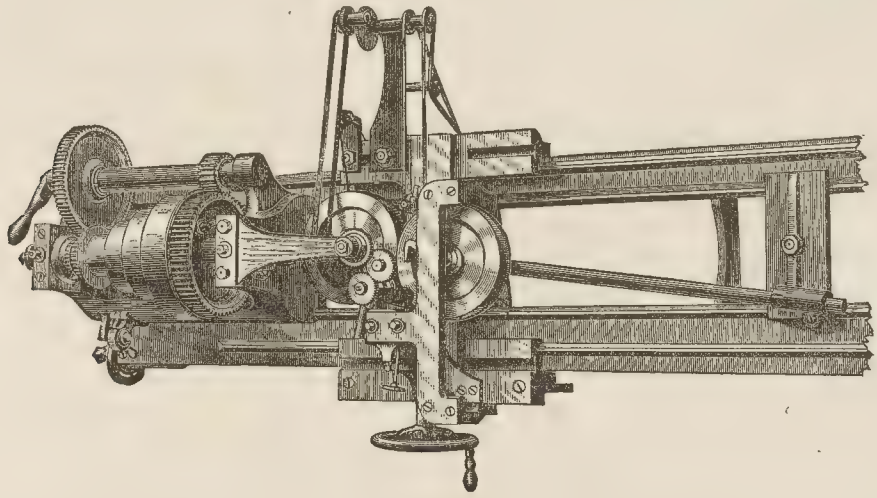


Fig. 313.

latter moved. But this objection is found to cause an inaccuracy of profile in practice so small as to defy detection. Very large wheels are always cut from a former, which guides the cutter. It becomes impossible to use a cutter which shall fully fill the spaces and reproduce itself in large pitches. Hence a cutter is used which dresses the profile by acting upon successive elements, with frequent traverses, and which is controlled by working up to a suitable former.

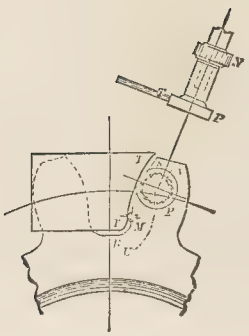


Fig. 314.

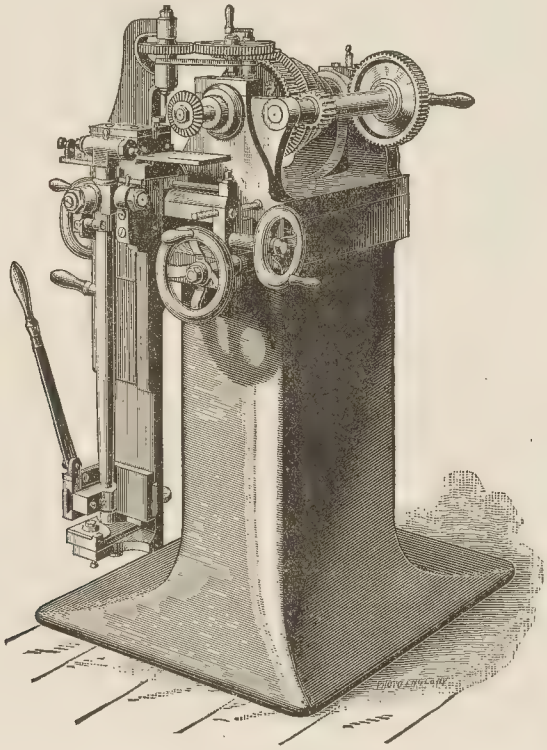


Fig. 315.

For bevel-gear the largest type of machine is that (Fig. 316) of Mr. Corliss, of Providence, Rhode Island. The blank is held upon a horizontal mandrel, on the end of which is an index-wheel of 15 feet diameter. By the use of such a large wheel any errors in it are reduced in the work. The blank is so secured that the apex of its conical surfaces shall coincide with the point through which the path of the tool-point always passes. By guiding the tool-slide by a large former, against which the rear of the slide shall be held, the path of the cutting-point at each

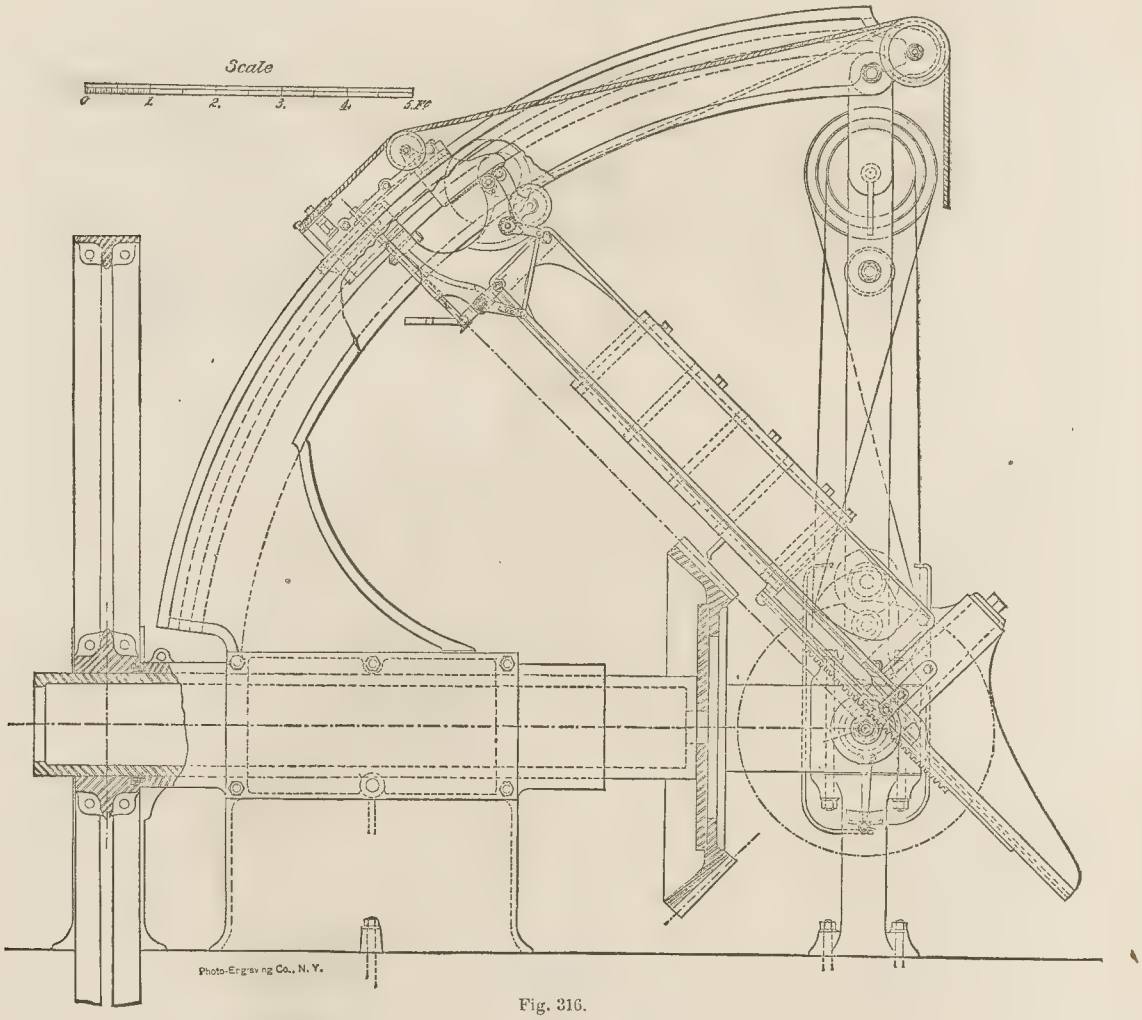


Fig. 316.

element of every tooth will pass through the apex and be tangent to an exact profile at the base of the cone of which the blank forms a short frustum. Profiles of great accuracy will thus result. A smaller machine on similar principle is built by the same makers.

Fig. 317 shows a gear-dressing machine by Gleason, of Rochester, New York. It will act on both spur- and bevel-wheels up to 100 inches in diameter. The wheel to be cut is mounted on the horizontal mandrel, which carries the worm-wheel and train from a crank. For iron wheels the tool-slide is driven by a crank from the central shaft in the upright post, whose center is the center of all cones in bevel-wheels. The end of the radial bar is laid off in degrees for convenience in this work. The tooth-former is put under the tool-holder, and the latter is fed over it. To dress wooden teeth inserted in rims or for patterns a thick circular saw is held in the tool-post, and is driven by belt over guide-pulleys from a radial drum overhead. The radial bar will swing to any angle with the mandrel between 0° for spur-wheels to 90° for crown-wheels. It is also hinged, to permit a vertical movement for bevel-wheels. With greater capacity than the preceding design, it is much less bulky and more rigid vertically.

Fig. 318 shows the Holmes machine working upon a similar principle.

While these latter machines scarcely belong to the class of milling-machines, yet they attach themselves so closely to the milling gear-cutters as to be presented at this point.

The milling-machine in its larger sizes, for locomotive, pump, and engine shops, is becoming increasingly popular. While at present practical considerations often overweigh the theoretical advantages which the tool possesses, and which would lead to its introduction, yet the tendency is toward higher appreciation of the value of

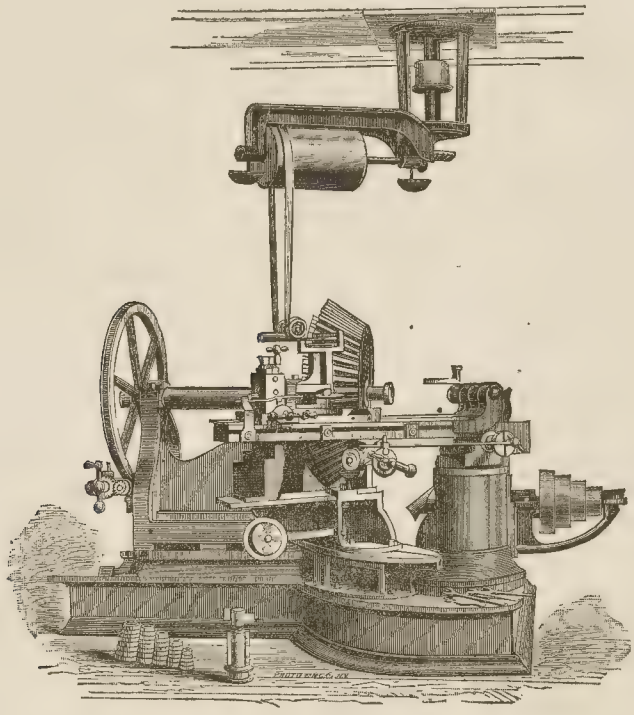


Fig. 317.

the tool. It may also by comparison be called a distinctively American tool in the forms in which it is most frequently met, because the greatest improvements in it have originated in the genius and necessities of this country. By its means production of certain specialties has been cheapened to a degree which would at one time have seemed entirely impossible with the existing high prices of skilled labor.

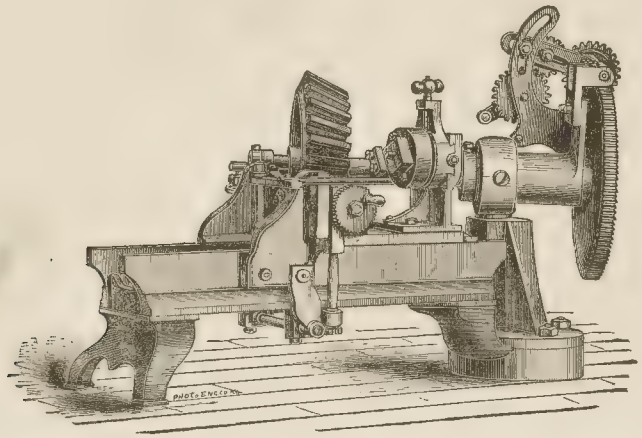


Fig. 318.

§ 33.

E.—TOOLS ACTING BY ABRADING OR GRINDING.

To this class belong the machines in which the conversion of material is not effected by cutting-edges of hardened steel, but by the attrition of revolving mineral. The work is presented to it, and the sharp particles of the stone abrade its surface. The abrading mineral is either the grindstone grit, emery, or corundum, and it may act to produce an especial shape of work or simply to produce a finish or polish on work already shaped.

A very large part of the duty of these grinding-tools is the production of cutting-edges upon hardened steel, that the softer metals may be cut by them. This shaping of the edges or sharpening of tools is the especial function of the grindstone. It is employed to smooth and polish in but few industries. The sharpening grindstone is held between flanges by a nut on a mandrel. The wedges around the mandrel should be just sufficient to keep the stone from throwing, while the flanges serve to hold it in place. The stone should have a speed at the periphery, varying with the class of tool to be ground upon it, from 200 to 500 feet per minute. Where hard tools for wood are to be ground with light pressures, the stone should go faster than for metal-working tools, which will be held more firmly. To compensate for the reduction of diameter as the stone wears, by which the speed at the periphery will become too low, the belt-pulley on the mandrel should be changed for one of smaller diameter at proper intervals. To prevent the annoyance and danger from flying grit and abraded particles, as well as to keep the steel cool, grindstones are run with water. The stone stands in a trough, which holds the excess of water and receives the particles thrown off. It is not wise to let the stone stand or run in water, on account of the softening action of water on the surface. The water is usually delivered from a pipe upon the stone when needed, the supply being controllable by a faucet.

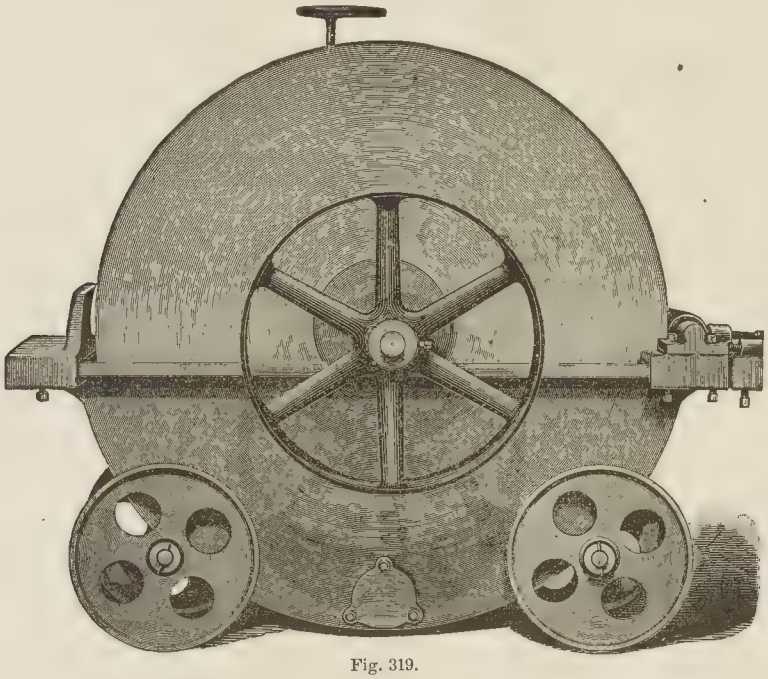


Fig. 319.

Fig. 319 shows a form of trough-mounting for a shop-stone. The stone is hung on a squared arbor, with long bearings, which are self-oiling and shielded to keep out grit. The boxes can be moved a few inches on the flat top of the trough, so that when the smaller pulley is put on after the stone has worn the belt need not be cut and re-adjusted. The rest is secured to the ledge of the trough by set-screws, and an adjustable self-turning attachment on the farther face keeps the stone round and its face true. This turning device consists of a steel screw, driven by the stone itself and pressed against it with any desired pressure by screws.

Fig. 320 shows a different design of mounting, the screw being linked to a hinge, so that the hand-wheel pressure easily engages or disengages it without special adjustment for equality of pressure upon the face. The water-can stands upon an upright at the side.

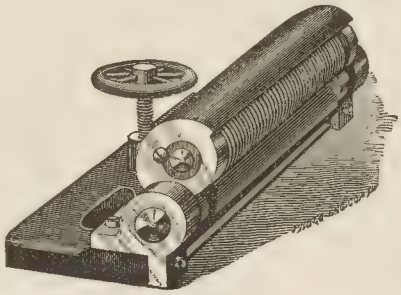


Fig. 320.

The modern grindstone-frames are mounted upon wheels. This has several advantages. The stand can be wheeled under a convenient crane or hoist, and the stone may be mounted or changed with ease. Secondly, when sufficient grit has gathered in the trough it can be wheeled to a convenient door or platform and there be hosed out through the hand-hole openings. By this expedient is avoided the overflow of gritty water, which may do harm, and is certainly untidy. In one design there are three wheels, the single one being swivel- or caster-mounted, in order that

it may be turned at right angles to the others and may resist the pull of the driving-belt. The wheel system further renders the maintenance of one belt possible with mandrel-pulleys of diminishing diameters as the stones wear.

Most of the grindstones in use come from Ohio or Michigan, or are imported from Great Britain or its colonies. They are of all grades of grit and hardness, which fact adapts them for the various purposes for which they are to be used. The fine, sharp grits are used for tool sharpening in shops.

Emery is used for tool sharpening in the form of the so-called solid emery wheels. These are molded disks of convenient size, made by cementing the ground emery to some vehicle which shall suitably carry it. These disks are mounted upon a mandrel and rotated at a high velocity. A usual velocity for average diameters is a speed at the circumference of 3,500 feet per minute. Small wheels often have a speed of less than 2,500 feet; larger ones are run at 5,000 feet or higher. While a large grindstone will remove a given quantity of metal in less time than an emery wheel, yet the emery-wheel can be made of a small thickness and of a shape which would be impossible in a stone. For milling-tools and for small machinery a wheel of small face will resist a lateral pressure which would crack a stone of same size and shape. The harder emery-wheel revolving at its high speed will do truer work also than the grindstone. This is independent entirely of the manufacturing capabilities of the emery-wheel, as in stove-plate work, wrought-plate work, fettling castings, small hardware, cutlery, etc.

The solid emery-wheel is an American invention. The special differences in the different makes arise from the qualities and defects of the cementing vehicle. This cement should possess certain properties. It must be strong enough in its cohesion to resist the centrifugal force due to the high speed of revolution. It must not soften, warp, split, or crack under heat or pressure, nor should it become brittle by cold. It must not dilute the emery too much by forming too large a percentage of the wheel mixture, and must permit such an intimate mixture with the emery as to produce a wheel of uniform density throughout with the same strength and texture. If it fails in this quality, the wheel will run out of balance in service, which is fatal to its usefulness and safety and durability. The cement must not glaze by fusion or combination with the cuttings, nor must it be so resistant as to make the work heat unduly from the necessity of wearing away the cement in order to get at the particles of emery. It would seem that an ideal cement to prevent these two latter difficulties would be one which wore away as fast as the crystals of emery lost their sharpness, so that the latter should be thrown off when their cutting qualities were lost. It will be seen, therefore, that the two conditions of free cutting and durability in a wheel are in a sense antagonistic, and the most that can be done is to effect a compromise. While, therefore, all should attain safety in use, durability and permanent sharpness cannot both be attained at once in any make of wheel.

Of the various cementing materials hard rubber or vulcanite was one of the earliest. Other makers use the gum from old leather acted on by acid, japan, and linseed oil, glue, silica with calcined chloride of magnesia, or "bittern" water, oil, and litharge, calcined chloride of zinc, celluloid and vitrified feldspar, or quartzose material. Most of these require the use of high hydraulic pressure in molds, a 12-inch wheel receiving a pressure of from 150 to 250 tons. One maker puts a circle of brass-wire netting in the center of the wheel to prevent accident in case of rupture. The same maker obtains the pressure for the mixture by the application of heat to the solidly-bolted molds. The hardness of the resulting wheel may be varied by the amount, by weight, of the mixture which is put in a mold of given capacity. The material undergoes a partial vitrefaction in the process of heating, by which the volume tends to increase. To secure balance in one make the four quadrants of the disk are filled separately, and are put in the mold in Russia-iron cells. Each of these is carefully weighed, so as to contain exactly the same weight of mixture when the cells are withdrawn. In the vitrified wheels the formed disk is exposed to a high heat in a kiln, by which the feldspar or its equivalent is partly fused and the wheel becomes as nearly like what a natural one would be as artificial means will admit. In one of these wheels the calcining makes the wheel porous, so that it is lighter in weight than when mixed. This permits the wheel to receive water at its axis and deliver it at its circumference, keeping the cutting-surface moist and cool without throwing an excess. Many of the wheels are fitted with a brass or lead bushing at the center, in order that a possible high temperature may not break the wheel by its expansion against a tightly-fitting mandrel. The wheels are held between flanges when at service, screwed up by a nut. It is often judicious to pad the flanges with leather, but is not essential with many makes. These vitrified wheels may also be run in oil for buffing or polishing work. More usually, however, this is done by wooden wheels, which are covered with leather on their face. The leather is coated with glue, and the emery is dusted on, or else the wheel is rolled in the emery. There are many of the cements which will not permit the use of water, and oil cannot be used on others. The glue wheels are likely to give off an odor in service.

To turn the emery-wheels to true cylindrical surfaces and to effect a complete balance the black diamond or bort is used. The wheel is chucked on a mandrel, and is faced on the periphery and on the ends. Any defect in balance is corrected by lightening the flat face. The wheels are graded by numbers. The lowest numbers, 8 to 10, give a duty about equal to that of a wood rasp; number 40 is about equivalent to a bastard file; number 80 corresponds to a smooth file; and 120 about equals a dead-smooth file. Flour emery gives a fine finish, without any especial sharpness of cut. The wheels may be molded and turned of any especial profile, as called for by varying classes of work. Some of these will be alluded to in the sequel.

Figs. 321 and 322 illustrate the ordinary form of emery grinder for general shop use. One carries two wheels, often of differing grades or profiles, with separate rests. One of the rests at least is arranged to act at the side of

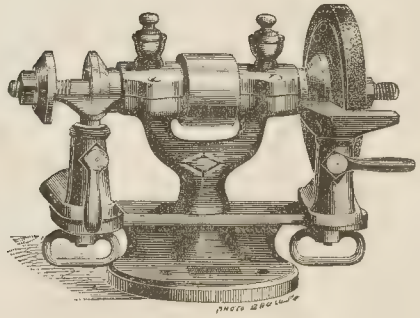


Fig. 321.

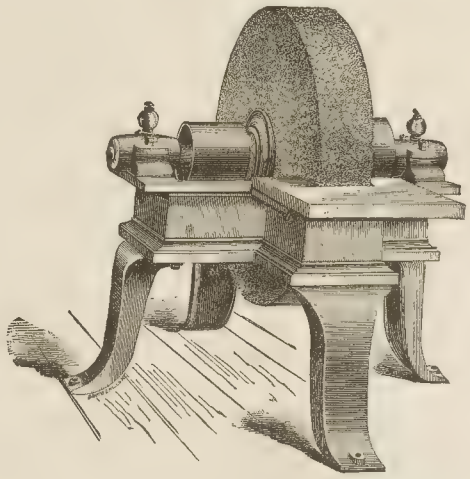


Fig. 322.

the wheel as well as at its face. One of the essential features of such machines is the proper protection of the bearing from the dust and grit which fly when the wheels are in use. In one design a ring outside the bearing is covered by a chamber in the long box, in which the grit will be caught.

Fig. 323 illustrates a compact standard grinder, with the self-lubricating boxes shielded by the cap. One of the wheels is plain, and the other is beveled for milling-gear cutters. A special attachment for cylindrical mills may be added.

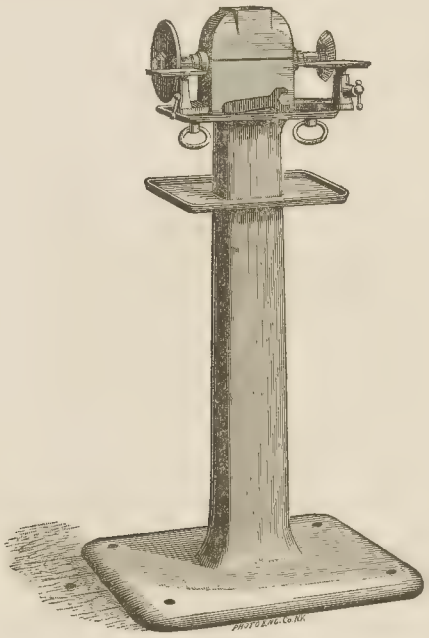


Fig. 323.

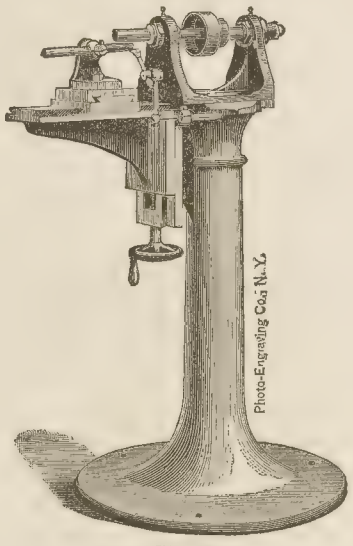


Fig. 324.

In Fig. 324 the grinder is especially designed for milling-cutters. A mandrel has a universal adjustment, vertical, lateral, and angular. An adjustable guide rests against the tooth which is being ground, by which the work may be gauged perfectly. Straight, taper, or spiral cutters may be ground with this machine, and it may use grindstones as well as emery-wheels.

Fig. 325 illustrates a double emery grinder, with universal milling-cutter attachment. The bracket swings to any angle and may be clamped, and a guide secures accuracy. Work may also be held on centers or in a vise.

A convenient form of bench machine, holding the cutter on a mandrel between centers which are adjustable, is shown by Fig. 326.

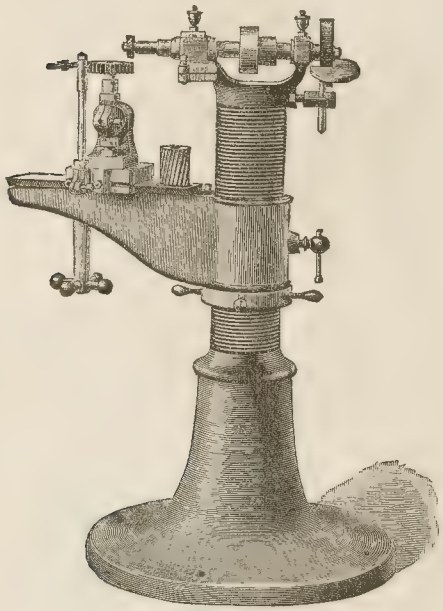


Fig. 325.

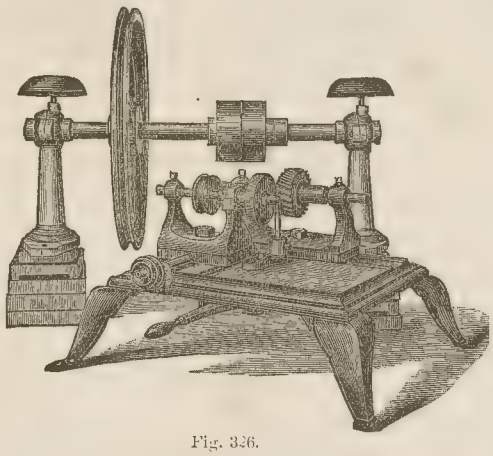


Fig. 326.

Of the special emery grinders perhaps one of the most important is the grinder for twist-drills. These should insure equal cutting duty on both edges and a proper relief or clearance while retaining them at a proper angle. Fig. 327 illustrates one form with the drill in position. The bar which guides the socket of the drill is placed at an angle with the horizontal traverse of the emery-wheel. This angle is experimental, and does not vary in the

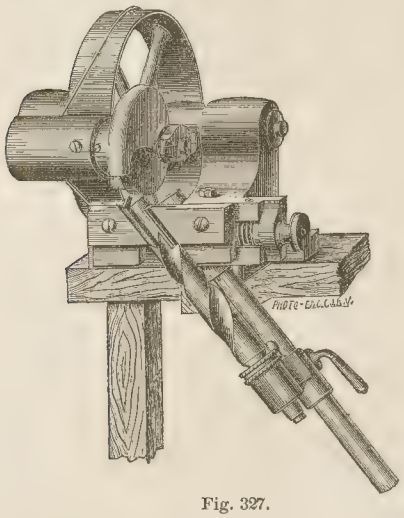


Fig. 327.



Fig. 328 *a*.

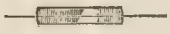


Fig. 328 *b*.



Fig. 328 *c*.

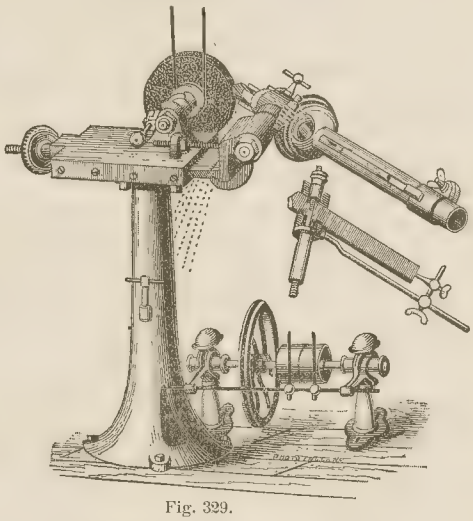


Fig. 329.

different makes very far from 45°. The drill is placed with its edge parallel to the path of the emery-wheel across the face, and receives clearance for its cut near the edge only. When one edge has been dressed to a true line the drill is turned on its axis through 180° by an index on the clamp for the socket. The vise at the lip is tightened anew, and the wheel makes its traverse.

For flat drills this tool gives all the clearance necessary (Fig. 328 *b*). Twist-drills require that the increasing clearance for the longer heel be given by hand, by backing off from the ground surface upon a second stone (Fig. 328 *c*).

In the machine shown in Fig. 329 the drill is held by a hollow spindle, which terminates in four jaws. These jaws are tightened upon the drill by worm and wheel. This spindle is attached to an horizontal arm which is not in its plane, making a projected angle of about 45° with it. This horizontal arm serves as center of motion for the spindle and the drill which it holds. As the lower end of the spindle is revolved upward the lip of the drill comes against the stone first. As the spindle is lifted further the heel of the edge is swung closer to the stone, and thus the relief is given. To secure equality in the two edges an adjustable stop abuts against the lower end of the drill, and the forward traverse of the emery-wheel may be controlled by stop-nuts upon a screw on the slide. The slide is moved by a hand-wheel. By this machine the lips of the drill will be of the same angle and length, will center in the axis of the tool, and will have clearance or relief increasing away from cutting-edge. This secures a durable edge to the drill, and the holes bored by it are more likely to be of the same diameter as the drill.

In the grinder shown in Fig. 330 the emery-wheel is a tub-wheel, which is a cylindrical wheel hollow in the

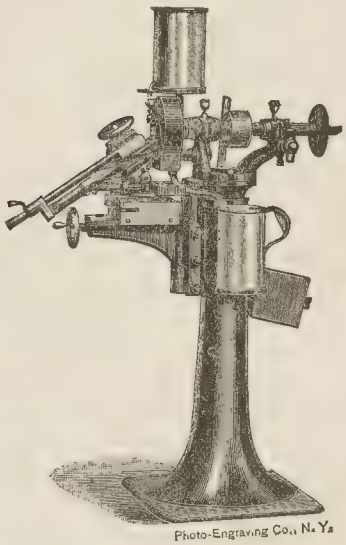


Fig. 330.

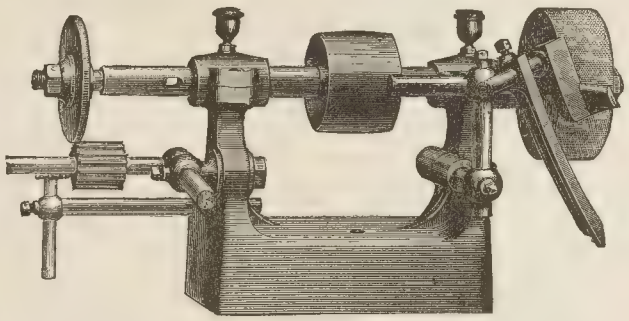


Fig. 331.

center, and which grinds upon the edge only. The builders prefer a vitrified wheel, which receives water in the middle of the hollow and delivers it to a drain below. The spindle is swung on a similar arm not in its plane at the proper projected angle. This arm is vertical. The drill is clamped by right-and-left screws, and the table which carries the vertical arm is moved toward the wheel by a feed-screw against stops for equal prominence of lip. The knee-table rises and falls by lever and counter-weight, so as to wear the face of the wheel equally. The edge is put vertical by a guide on the jam of the holder, and the amount of relief may be varied by loosening a large central screw. A similar machine with mill- or shell-reamer attachment is shown by Fig. 331. The articles to be ground are properly supported, and are presented to the stones by hand only.

Emery-wheels are also successfully applied for grinding the knives of wood-working planers and saws. Such a machine is shown by Fig. 332. The wheel used is known as a tub-wheel, which grinds upon the end only. By the use of this form the concave edge is avoided, which will be caused by the use of the face of a disk-wheel. Stop-gauges compel the knives always to stand at the same angle so as to receive the same bevel at every grinding, so that no unnecessary metal is successively ground away. The knife-carriage is fed back and forth by power. For sharpening saws the face of the further wheel is beveled and the saw is held upon a mandrel on a slide. The usual profiles for these "saw-gummers" are shown by Fig. 333, which also illustrates forms which may be required if the second wheel be intended for the cutters of wood-molding machines. Fig. 334 shows a gummer mounted upon universal joints, by which it can easily be presented to its work.

But in addition to its uses as a tool-sharpener the emery-wheel and grinder may be applied as a shaping-machine for general or for special manufacture. It can only be used with economy upon surfaces which are *nearly* correct, or upon those for which the reciprocating or milling cutter are not applicable. To this class belong the tools for acting on hardened steel, and for shaping and removing the fins from sandy castings. Fig. 335 illustrates a special machine for this latter duty, where beveled surfaces may occur frequently. In place of the conical wheel any other shape may be used, or a pot-wheel may be put on for dressing the inside of hollow ironware. The

table can be tilted for any degree of bevel, and the spindle is carried in boxes upon a guided cross-head, which may be lifted by the hand-lever. By the use of false tops with centers and clamps stove plates may be turned and beveled with great rapidity, and the machine may be applied to a variety of miscellaneous work. Horizontal grinders are also applied very generally for this type of duty.

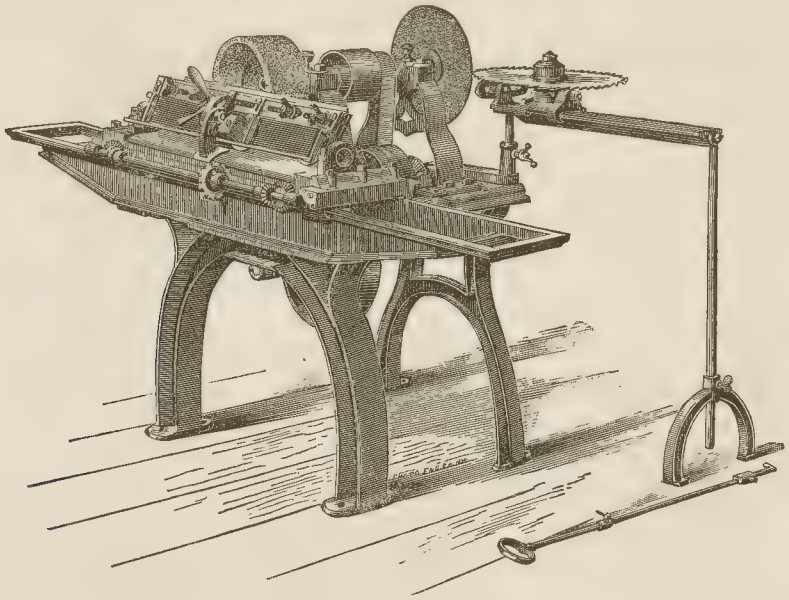


Fig. 332.

For work upon hardened-steel surfaces of revolution the lathe shown by Fig. 120 has been alluded to, with the emery-wheel mounted on the carriage and receiving a traverse motion automatically from the driving-head. A tool of similar principle is also used for grinding into approximate truth the treads of chilled car-wheels. Both wheels may be trued at once as they revolve with their axle held between centers. The emery-wheels are fed by a slide-rest mounting. For grinding taper work, straight or curved, as well as cylindrical pieces for arbors, cutters, etc., the machine of Fig. 336 has been designed. There is a movable table on the top of the primary, which may be swung around its center by a tangent-screw and graduated arc, so that the centers are always truly in line. The longitudinal feed is by rack driven from open and crossed belts, which are clutched to the train by appropriate stops on the table. The clutch cannot stall, because the device of a spring wedge is applied to it. By this machine straight and taper holes may be ground, such as hardened boxes and standard ring gauges. The

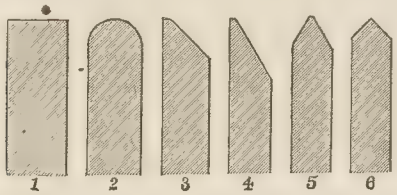


Fig. 333.

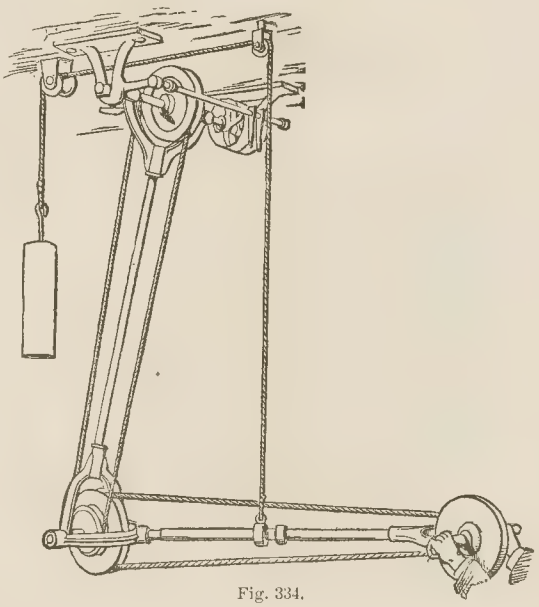


Fig. 334.

wheels may be used with or without water, and all the working surfaces and slides are protected. Wheels from one-fourth of an inch to 12 inches in diameter may be used. Graduated arcs assist in setting the work for taper grinding either external or internal.

Figs. 337 and 338 show similar machines.

For flat and true surface grinding and finishing of hardened or soft work the machine of Fig. 339 has been designed. It is to act as an effective substitute for filing, scraping, and stoning. An emery-wheel is hung from

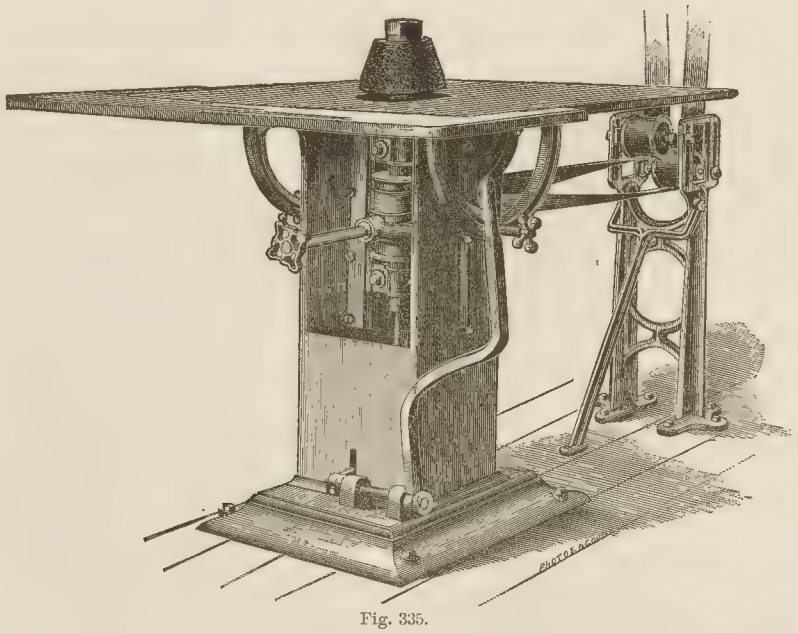


Fig. 335.

the cross-head, and is driven from the long drum at the back. The adjustment of the cross-head takes place around the axis of the drum as a center. The table is fed by a planer-gear with open and crossed belts, and the wheel-saddle receives a feed from a friction device through sector and ratchet. For punches, dies, flattening-dies,

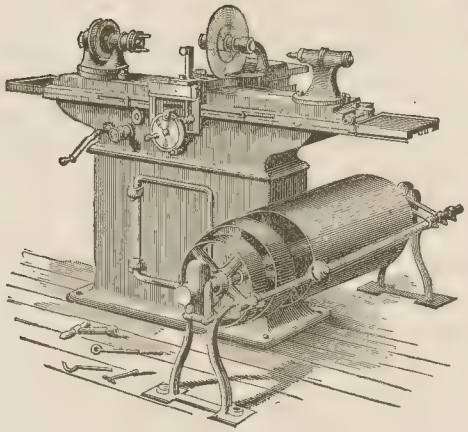


Fig. 336.

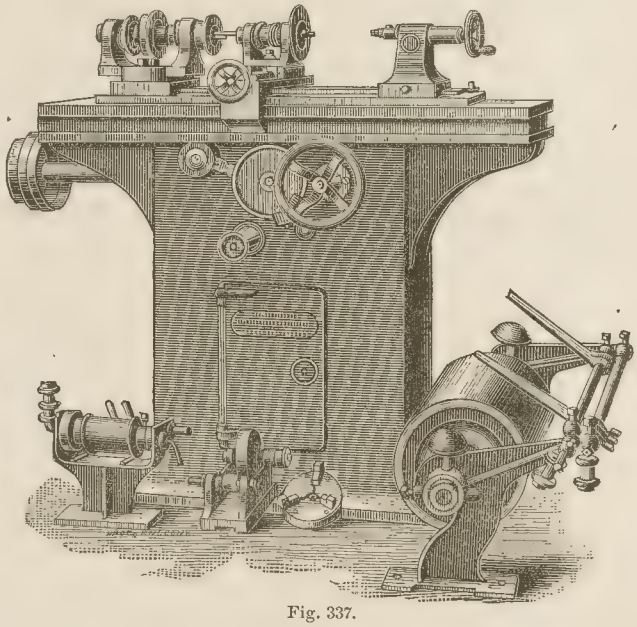


Fig. 337.

straight-edges, and work of that class, this machine is claimed to save three-quarters of the labor usually expended, and to replace the cost of files by that of the more lasting wheel. It is a machine which is a symptom of the demand for a higher grade of workmanship in many branches of shop-work.

For polishing purposes, the solid wheels are not much used, because a polishing-wheel should glaze, while a cutting-wheel should not. A few which can be run with oil may be used for polishing. More usually, however, for

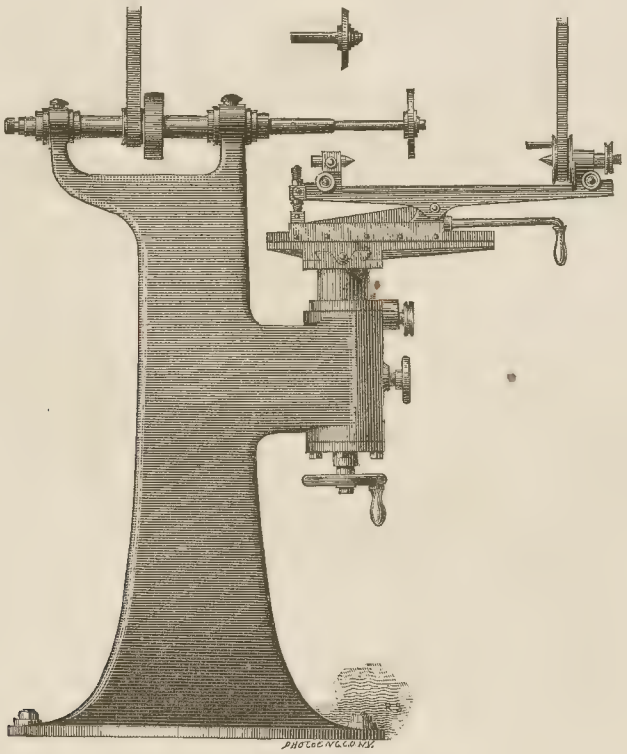


Fig. 338.

this service, as already stated, emery is used upon a leather face glued to a wooden wheel. This wheel is built of overlapping sectors, breaking joints, of selected wood which will not warp. These can scarcely be called emery-wheels, however.

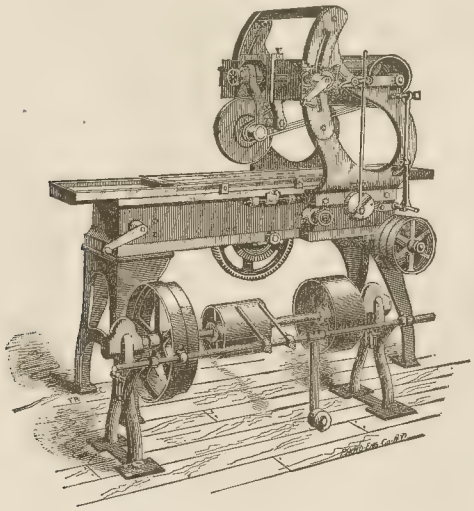


Fig. 339.

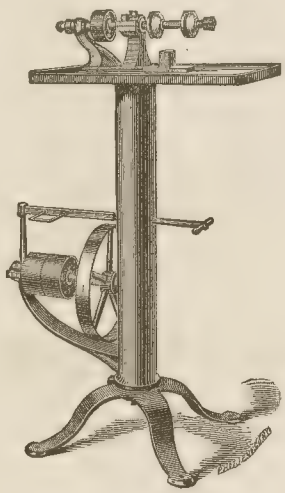


Fig. 340.

For fine buffing a leather-covered wheel is used, upon which the successive grades of emery may be used loose, from the coarsest to the finest required for the finish in question. For the most brilliant luster on brass-work

a felt or cloth wheel is used, often known as a "rag wheel". Disks of the flexible fabric are secured between flanges, and centrifugal force gives them the necessary stiffness when revolved at high speed. Crocus-powder is used for the last polishing with wheels of this class. Their great difficulty is the jarring and chattering, due to lack of proper balance, which is increased by the leverage due to the usual overhang. The journals are apt to give trouble. In the machine of Fig. 340 the long central journal is tapering, and the other is cylindrical, with a tail-screw. By this means any vibration can be taken up. This machine is also adapted for light tool-grinding, with solid wheels. Its avoidance of end-play gives it special advantages for certain classes of such work. Special patterns of simple machinery for grinding hardened-steel rings on their faces are in use. The ring revolves by friction of a pair of cast-iron rings, the pitch lines of the steel and iron rings intersecting each other. The pair of iron rings may be made to compress the steel ring between them with any desired pressure, and the grinding is done with powdered emery and oil.

§ 34.

TOOL-ROOM.

A discussion of the machine-shop tools driven by power would be incomplete without a supplementary allusion to the contents of the tool-room. Every large establishment has a space devoted to the storage and repair of those hand-tools which need not necessarily form a part of the outfit of each operator, but which may be common property, accessible when needed. Every machinist either owns his own hammers, wrenches, scales, callipers, and the special gauges needed for his machine, or else they belong to the shop, which holds him responsible for their safety in his kit. Files and chisels which wear rapidly often come through the supply-room, and are kept separate from the more permanent tools. In some shops these two divisions are combined.

In shops which do any outside repairs or large erecting hand-drills will be required. For very small holes, where but little pressure can be put on the feed, the breast-drill will be of service. For heavier work the ratchet-drill is best (Fig. 341). The conical step at the top abuts against an arm clamped to the work. For very heavy drilling the ratchet-arm may be extended by slipping a piece of pipe on it.

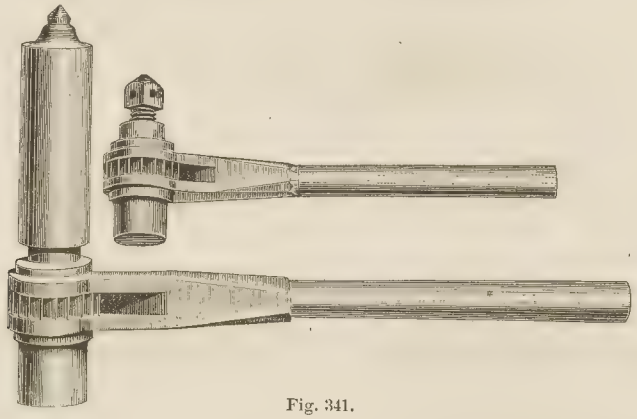


Fig. 341.

Fig. 342 illustrates an improved device by which the pawl on the arm may be either right or left handed, or may be disengaged entirely. The cut also shows how sockets may be introduced to accommodate drills with shanks of different shape.

The tool-room usually contains a full complement of drills of the usual sizes, and often those of unusual sizes. Those in most frequent use are often racked upon the drills themselves, the tool-room having duplicates. These drills consist to-day of a majority of flat or fly drills, which are gradually being displaced by twist-drills (Fig. 343). This displacement is in some shops complete. It will probably be so in all before long. Twist-drills are made with the taper shank as shown, or straight. The taper largely predominates. The newer ones are scribed with a grinding line on the hollows of each side. By working to this always the cutting-point will always be in the axis of the drill, and the hole drilled will be no larger than the drill. The drill-presses are fitted to receive a socket in a taper hole in the end of the spindle. This socket may either be keyed in the spindle by a steel key through a slot in both (Fig. 344) or the fit may be by friction. Sockets of different sizes will be used for larger or smaller drills. Those not in use will be in the tool-room, as well as special sockets for odd sizes. The milled tail of the shank prevents the butt of the drill from getting marred, so as to spoil the fit in the socket, and also permits of light keying in the slot. If pin-drills are called for by the requirements of the shop service, they will be kept here. They will be used for boring out a large hole, for which a small hole has been made in the axis as a guide.

For accurate cylindrical holes the simple drill will not answer. It will not necessarily produce a hole either straight or round. It is necessary, therefore, to bore the hole a little small with the drill and bring it to standard size by a reamer. The solid reamer (Fig. 345) enters the hole by a short taper, and enlarges it to the size desired. For very rapid work, as in bridge-plate, and especially for punched steel plate, the self-feeding reamer is approved. The short thread carries the tool rapidly forward (Fig. 346). For certain metals the reverse of this is desirable,

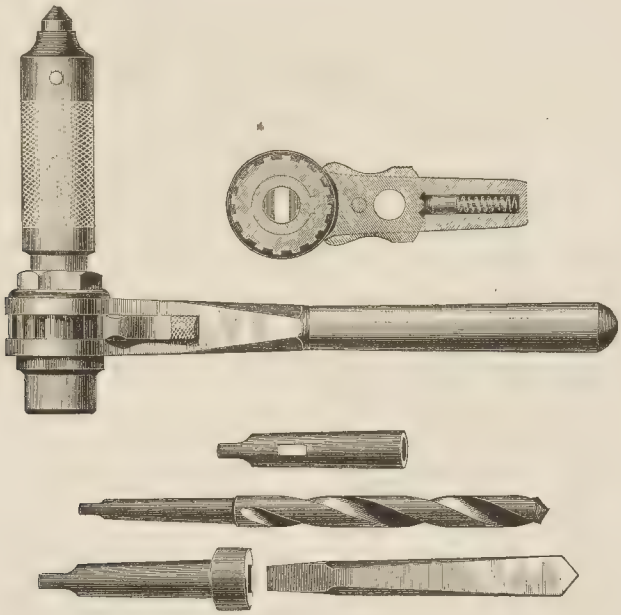


Fig. 342.

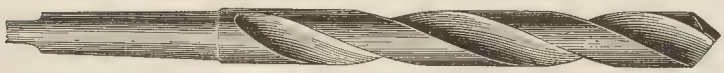


Fig. 343.



Fig. 344.



Fig. 345.



Fig. 346.



Fig. 347.



Fig. 348.



Fig. 349.



Fig. 350.

and even the plain reamer may feed itself too rapidly. To meet this case the relief reamer has the flutes inclined backward, so that a dragging cut is produced (Fig. 347). The shell reamer works upon a central guiding-spindle (Fig. 348), and the taper reamer (Fig. 349) acts simply to enlarge a hole without exact regard to its truth. The rose reamer (Fig. 350) is usually arranged to be chucked in a taper socket, for producing countersinks and similar duty.

After the production of the holes will be the cutting of screw-threads upon them if they require it. Fig. 351 illustrates the usual forms of taps for bolt- and nut-work. Fig. 352 is the long tap for threading the two surfaces of stayed work so that the screws may fit both.

Fig. 353 illustrates the usual form of pipe-tap, with the standard threads for gas and steam fitting. Fig. 354 illustrates a larger size, with inserted cutters in grooves in the body of the tap.

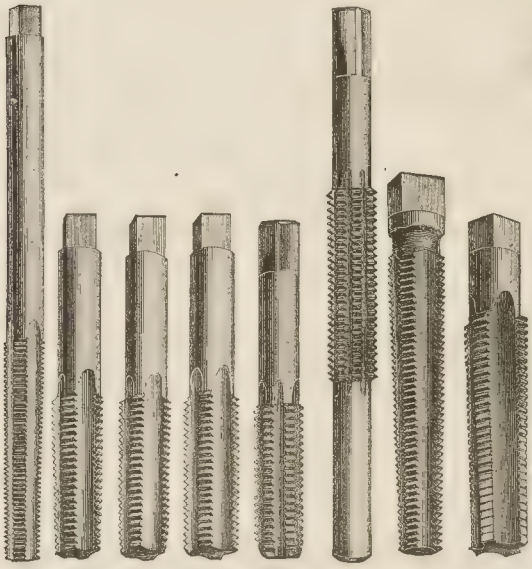


Fig. 351.



Fig. 352.

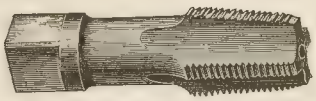


Fig. 353.

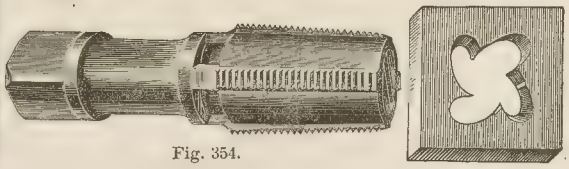


Fig. 354.

For turning these taps a special form of two-handed wrench is used. Fig. 355 shows one form, where the two halves of the square are closed by screwing in one handle. In the other form (Fig. 356) the two halves are brought together by a milled scroll disk and held by a latch.



Fig. 355.

For cutting the threads upon bolts and studs by hand a stock with open dies is mostly used. The dies are either milled to fit tenons in the sides of the opening of the stock, with a blank distance-key in the bottom, so that the dies may be changed, or some improved device is used.



Fig. 356.

Fig. 357 illustrates a convenient one, in which the dies are held by the long arms of the bent levers, which are tightened in sidewise by the pressure of the adjusting binding-screw. When this latter is released, pressure on the stud releases the dies. So simple an arrangement is this that it may be wise to use the stock as a tap-wrench by replacing the dies by blanks.

Figs. 358 and 359 show details of stocks and solid adjustable dies which cut a thread with one going over. The details for taking up wear will be visible from the cuts. For pipe-dies solid dies are most usual of the form shown by Fig. 354. These are held in a stock of the shape of Fig. 361, which has a leader-screw for securing the

proper starting of a large thread. This will be used only for sizes over one inch. Bushings serve to guide the die straight. For small work not infrequently the combined stock is used (Fig. 362), the dies being laid in and covered with the cap-plate as in the larger sizes. Above 3-inch pipe the stock must have sockets for removable arms, because otherwise the vises would not be high enough to let the longer arms clear the floor. There are usually

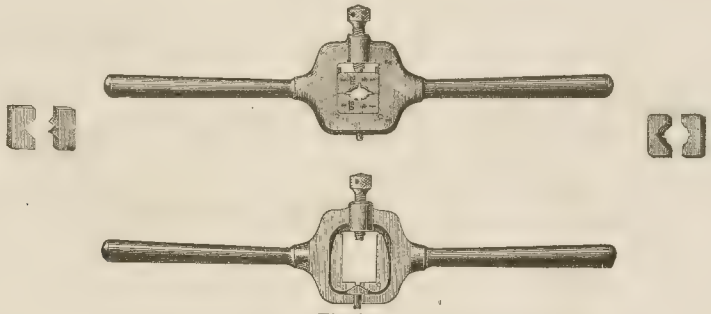


Fig. 357.

sockets for four arms. A great deal of shop-work on pipes is now done by machine. Su an outfit will be for job-work only. Cutters and tongs for the different sizes complete the set. Fig. 363 illustrates an open die-stock. The compression and adjustment is effected by the screw, which is capped over by the hollow handle.

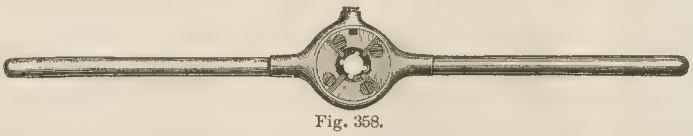


Fig. 358.

It has long been recognized as a corollary to the system of the division of labor that greater accuracy of calibration is necessary than the ordinary scales and calipers will admit. When a number of different men are working at different parts of a job which is finally to be assembled it is only possible to economize time in the

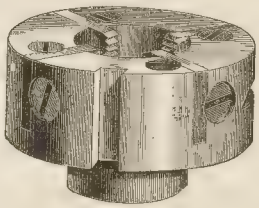


Fig. 359.

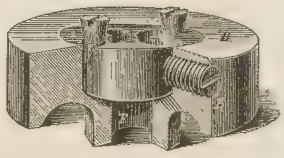


Fig. 360.

fitting operations by securing very great accuracy of dimension. To secure this end many of our best establishments have in their tool-rooms a set of standard gauges, external and internal (Figs. 364, 365, and 367), which are of hardened steel, and are used to set the common calipers, instead of graduated scales. Were they used as

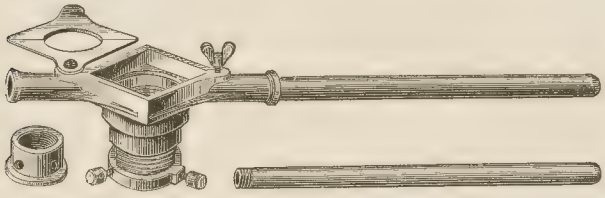


Fig. 361.



Fig. 362.

gauges in the shop, the wear on the hardened steel would be enough to destroy their accuracy. They may be used to test a set of shop standards, which may be thrown away as they lose their truth. For general shop use several of the exact-tool makers are making the type of gauge shown by Fig. 366 for external and internal calibration. They may be of steel, or one builder is using wrought iron, case-hardened, as preferable. The form of screw-thread

gauge is shown by Fig. 365. For fine calibration and adjustment of special tools a tool-room often requires vernier calipers. Figs. 368 and 369 illustrate two forms of differing capacities. These will both read by the vernier down

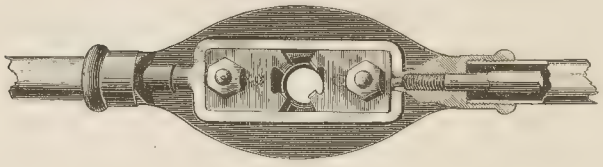


Fig. 363.

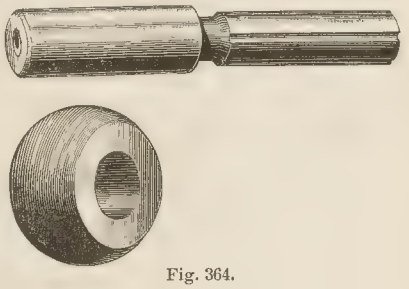


Fig. 364.

to one-thousandth of an inch. The smaller one has an adjustment to secure accuracy after wear. These are not in general shop use as yet for larger types of work. Special gauges, scales, straight-edges, surface-plates, angles, rules, and standards may be called for over and above these for special branches of manufacture. A very few of the shops are provided with an especial machine for exact measurement. By micrometric devices these will read to a high limit of exactness. It is not within the scope of this discussion to describe them more fully.

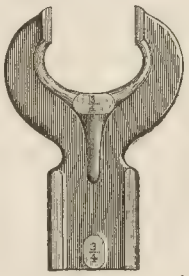


Fig. 366.

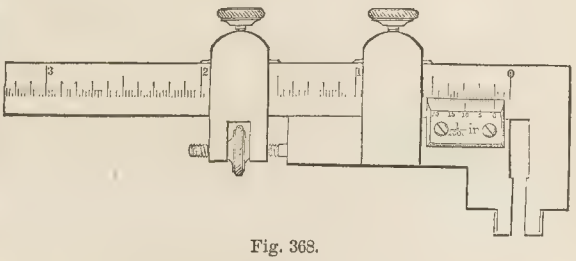


Fig. 368.

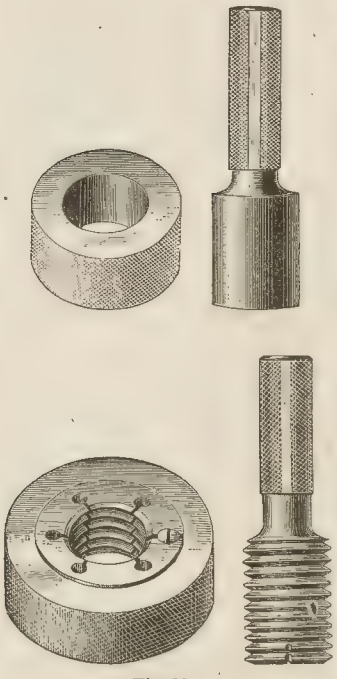


Fig. 365.

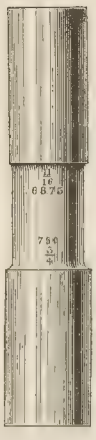


Fig. 367.

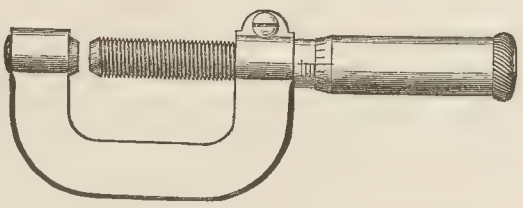


Fig. 369.

Where milling-cutters are used in any variety the tool-room furnishes them and usually keeps them in order also. For all the work on tools in the tool-room, both general and special, the machine-tools characterized by their universality and exactness are best adapted. It is for such uses that the milling-machine and the emery grinders are very frequently applied.

§ 35.

It has not been thought necessary to enter largely into the subject of the linear capacity of the tools discussed. Such information is easily accessible to those who wish it. Neither has special commendation been awarded. Those who are expert in such matters will detect from the descriptions those features which deserve it. But it may not be amiss to call attention to two points which have had a great influence in raising the standard of machine-tool manufacture in this country. The first is the increasing respect for the small decimal subdivisions of the inch and a more complete understanding of their significance. This is manifested in the prevalence of the use of exact standard gauges, and by the increased strength and stiffness of the designs of the newer tools. It is understood that properly distributed weight of metal is necessary and desirable, and a heavy tool will do light work far more accurately than a light one can do heavy work. By proper resistance to the strains of the cut the tool is *expected* to do exact work, and its designer and its maker do not and should not rest till it accomplishes that end. The second point is the increasing prevalence of hand-scraped surfaces, tooled with a hook-scraper and worked up to true planes. The use of the file and emery-cloth to produce a finish pleasing to the eye only, while the surface was mechanically untrue, is a thing of the past in our best shops. By this advance every bearing surface bears all over, and not at a few points only. Wear is diminished, and the motions take place in true straight lines.

A third point might be the extended use of hardened steel, ground and lapped. The truth of the fit originally made by the maker remains for a long time to benefit the user.

It is for these reasons, and for others which might be adduced, coupled with the mechanical genius of their designers, that American machine-tools have reached the degree of excellence which characterizes the best of them.

PART II.—WOOD-WORKING MACHINERY.

§ 36.

It is proposed to discuss the class of wood-working machinery between the limits which are parallel to those established for the machine-tools. The forest-sawing of the lumber will be considered as preliminary to the tools in question. This is the limit parallel to the metallurgical tools and processes for the metals. It is equally out of the aim of this section to enter on the subject of the special tools which have an important bearing in one or two lines only of special manufacture, such as chair, barrel, sash and blind, wheel machinery, and the like. This limit corresponds to the further limit of the previous discussion. Between these two limits lies a large class of those general tools which are of universal or extended application in house- and car-building and in the pattern- and carpenter-shops of engineering establishments. These are of primary importance, and will be brought under notice.

The differences between the metals and the woods give rise to very marked differences in the structure and in the action of the tools for the two classes of material. On account of the softness of the woods relative to the cutting-edges, wood-workers permit and demand that the conversion into the required shape should be rapid. Revolving cutters will therefore predominate, and they will be driven at the highest speeds. The high speed is also necessary on account of the fibrous character of the woods. At slow speeds, the surface would be more likely to be torn than to be cut by the shaping-edges. It is the existence of the fiber or grain of the woods which gives rise to the different methods by which wood-working tools operate. These are:

F.—By scission.

G.—By paring.

H.—By combinations of these two.

I.—By abrading.

The tools acting by scission are those which act to sever the fibers of the woods across the grain. This class includes the numerous varieties of saws. They might also be called tools acting by disintegration, since they penetrate and shape by reducing the material in their path to a fine dust. The second class, which acts by paring, would include those which produce shavings or chips by acting upon the fibers in the direction of their length. Such would be the surfacers, planers, matchers, friezers, and molders. The tools of the third class would be those which act upon the fibers both lengthwise and crosswise. They must therefore partake of the capacities of both the others. Such are the lathes, boring-machines, the mortisers, rotary and reciprocating, and the gaining-machines. In these tools there must be a spur or saw-segment to sever the fibers before the chisel-edge can pare away neatly the material to be removed. The class of machines acting by abrasion or grinding includes the sand-paperers and the like. These, however, are rather for ornamenting or finishing the work of other tools, and are therefore secondary. It is the saw and the chisel of the handicraftsman which furnish the basis of all the wood-working machinery. The plane, the gouge, and the bit are themselves deductions from the primary two. The sand-paper and the file are the originals of the abrading-machines.

§ 37

F.—SAWS.

RESAWING-MACHINES.

There are several reasons why the forest-sawing of lumber to small dimensions is impolitic. It is best to make the logs up into squared stock only, and thus to transport them to the purchaser. Among these reasons are that the thin green lumber will warp and dampness and sun will check the ends. There will be great loss of lumber from the wide kerfs of the log-saws, and the grit, which will adhere to the great surface exposed, will induce the surfacers to take a heavy chip to get under the grit, so as to avoid ruining their knives. For these reasons, and for others connected with the storage of the lumber in yards, machinery for resawing squared stock, either seasoned or kiln-dried, has become of increasing importance as lumber becomes more valuable.

Resawing machinery is of three classes. The first includes the vertical reciprocating saws, the second includes the circular resaws, and the third embraces the band resaws. There are certain features which are, or should be, common to all. The planks are presented vertically to the saws by the means of four vertical rolls, which are driven by power. These may be arranged to center equally upon the saw, so that it shall bisect any plank

presented to it, or one pair may be clamped at one side, so as to act as a guide to insure that equal thicknesses shall be cut for every board. In this case the other pair yields slightly, to compensate for varying thicknesses of the rough stock. For bevel-siding, for clap-boards and similar work, the whole roll-mounting may be swung so as to present the lumber obliquely to the plane of the saw. Their other functions must not be interfered with in this case. Several special features will be alluded to in the sequel.

Fig. 370 illustrates a simple open type of vertical resaw. The saw is strained in a sash or gate of wood, driven by two pitmen from the balance-wheels overhead. Wood is used for the sake of lightness. The feed is given by

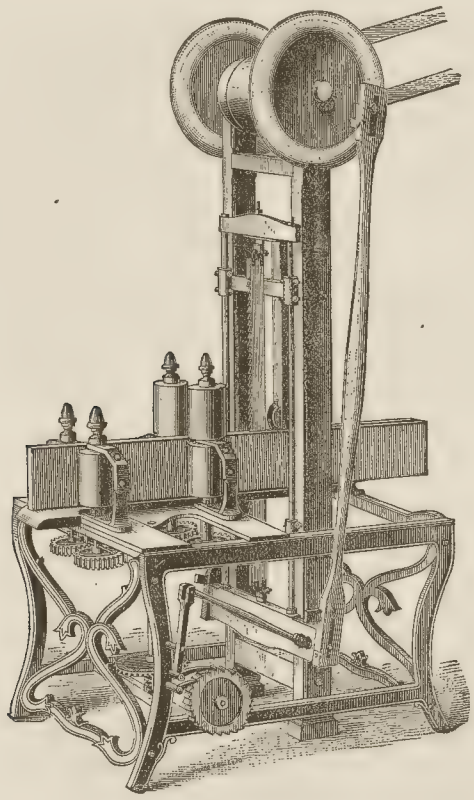


Fig. 370.

lever and dog from the gate to the gears on the roll-spindles. The stock is kept from rising by an adjustable roller, which carries a flange, and acts to wedge open the cut. The rolls have their secondary bearings adjustable. The intermittence of the feed relieves the saw in part on the up-stroke.

Fig. 371 shows a larger and heavier type, with the balance-wheels below. The pitmen have adjustable stub-ends, to take up wear and to insure equality of length. The rolls are driven from a separate belt-wheel, and are adjusted laterally by the levers and links from in front. A spiral spring controls the feeding pressure, and the feed is continuous. An adjustable weighted device keeps the plank from rising with the lift of the saw, which tendency is increased by the continuous feed. A still larger type is shown by Fig. 372, where the gate is of iron and the pit below accommodates the pitmen and wrist-plates. The gang-saw, with several plates in one gate, does not seem to have been generally applied for fine resawing. It has been approved for heavier work more extensively.

The strained vertical saw has the advantage of economy of kerf. A very thin blade may be used, and made wedge-shaped in section. To be opposed to this is the slow speed of feed—from 4 to 6 feet per minute, according to the width of the board. This is due to the necessarily slow speed of reciprocation, and to the fact that the saw is cutting during only one-half of the time.

The circular resaw is in most general use at this date. It has the advantage of continuous cutting action and high cutting speed. Its disadvantage is the wide kerf which must be cut. The saw-plate must be thick enough

to retain its stiffness when at work and under the action of centrifugal forces, and to attain this, greater thickness is demanded than in strained saws. Various devices to secure stiffness with small kerf-losses are exhibited in the various designs.

To compensate for the wear of the saw most of the designs have the mandrel-boxes adjustable, so that the saw may be kept close to the guiding-rolls. A smaller saw can also be thus admitted. The front rolls must be very close to the saw, inasmuch as the top part only cuts when the stock is over the mandrel. The front rolls are often made longer than the back ones.

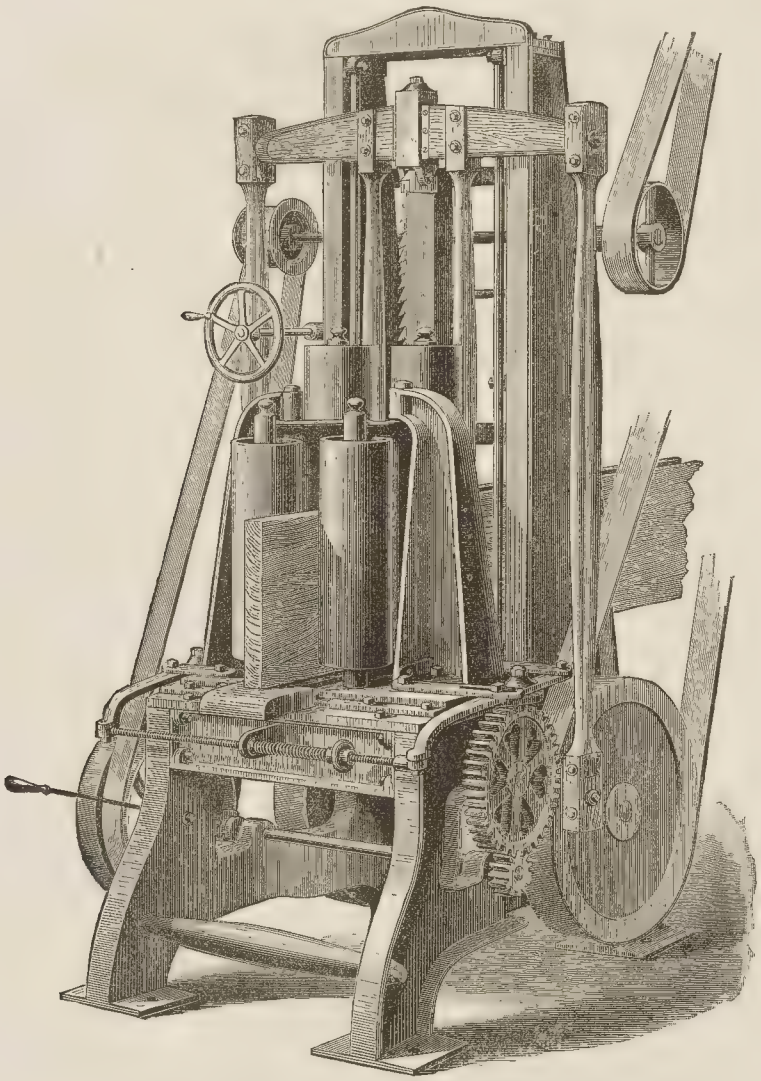


Fig. 371.

Fig. 373 shows a thin saw stiffened by a flange, to which the blade is screwed. The other side is flat, working against the stiff stock, while the flexible board is wedged away so as to prevent the plate from heating. The feed is given by reducing-gear from the arbor, but is still at high speed. The pairs are connected together by gearing on top, and receive their motion from the bevel-gears on the splined shaft below. The gears slip on the shaft laterally to permit the adjustment for varying thickness of stock. The bent lever and weight act upon a double wrist-plate to center the rolls upon the saw. The rolls are supported in long bearings in saddles upon a slide below. This is a very usual arrangement. The slide casting may rock upon a central pin for bevel-sawing. It is adjusted by a screw, and further clamped by the hand-nuts in the slots of the arc.

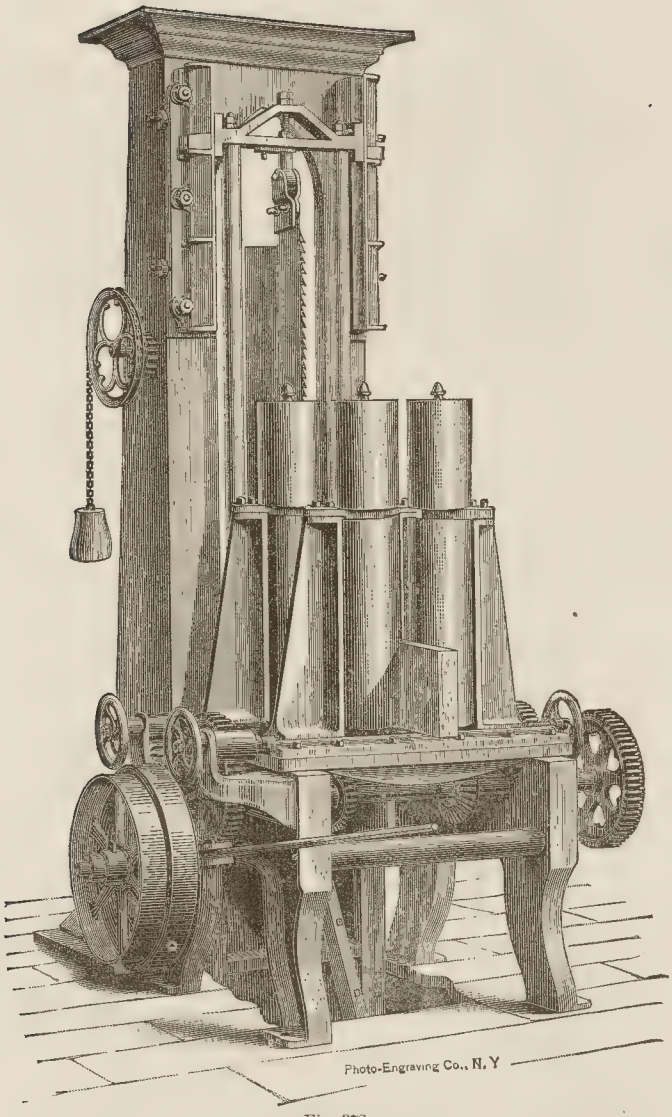


Fig. 372.

Fig. 374 shows a machine with taper-ground flanges on the saw, permitting the use of thin saws. A pair of friction-rolls project well over the plate to guide wide stuff near the cut. The weighted lever acts by equalization,

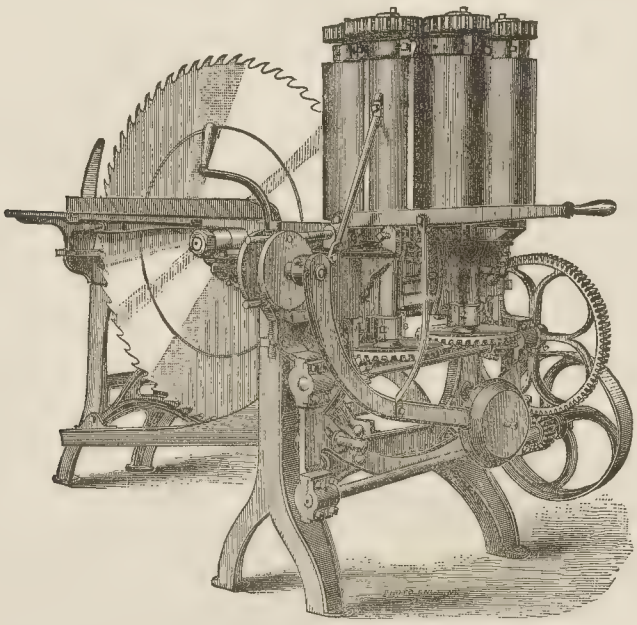


Fig. 373.

so that either center or side cuts may be made. The whole feed apparatus will swing for bevel-sawing, and the feed may be arrested by a clutch at the right. Dust is caught in a trough, which also shields the bottom of the saw.

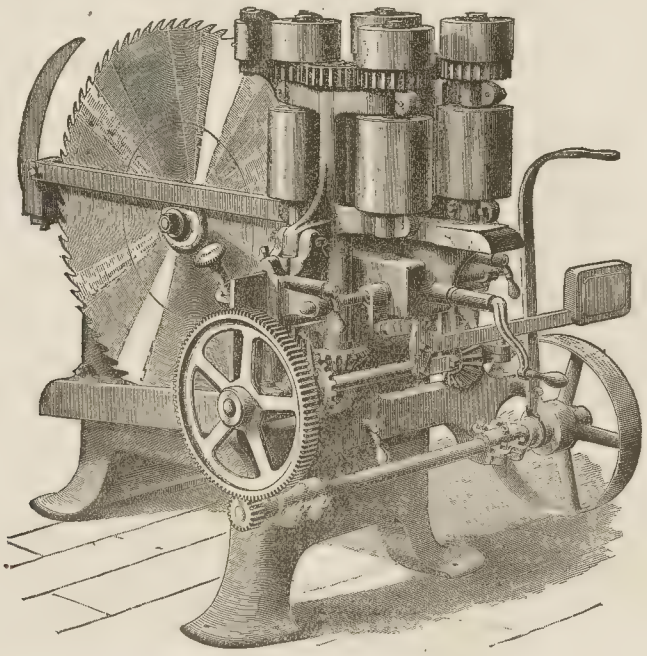


Fig. 374.

Fig. 375 shows a saw with inserted teeth. By the incidental use of softer plate this system also gives a thin kerf of less than one-eighth of an inch with a 50-inch saw. The rolls are mounted on separate slides, which are

inclined so as to be normal to the resultant of the weight of rolls and stock and to the push against the latter, due to the cut. The rolls are steadied by adjustable ring-bearings, by which inclination of their axes is permitted. There are three changes of feeding speed and a disengaging-clutch. All adjustment of the rolls, from center to side cutting, is effected from the feeding end by hand-wheel.

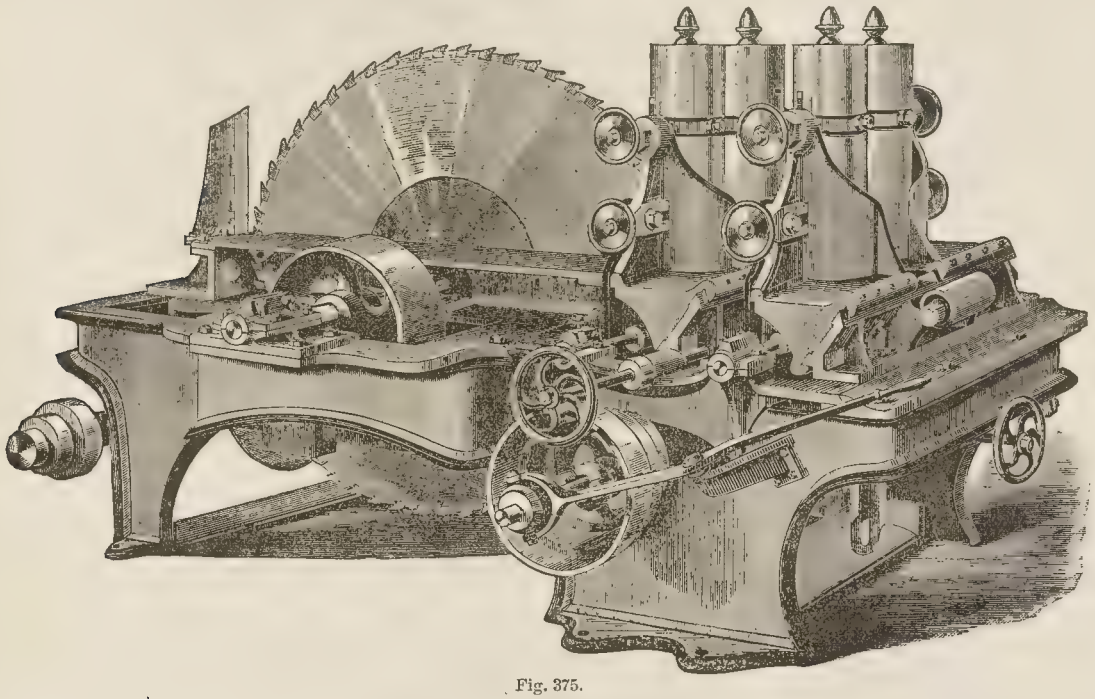


Fig. 375.

Fig. 376 illustrates a type which has some special features. The saw is guided by end-wood adjustable guides at both ends of the horizontal diameter and at the top. By this principle of guiding a great reduction is possible

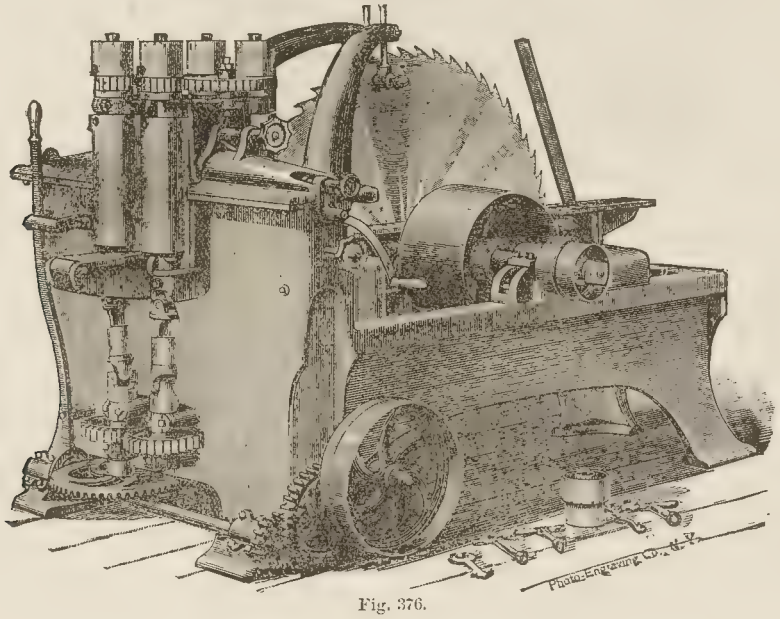


Fig. 376.

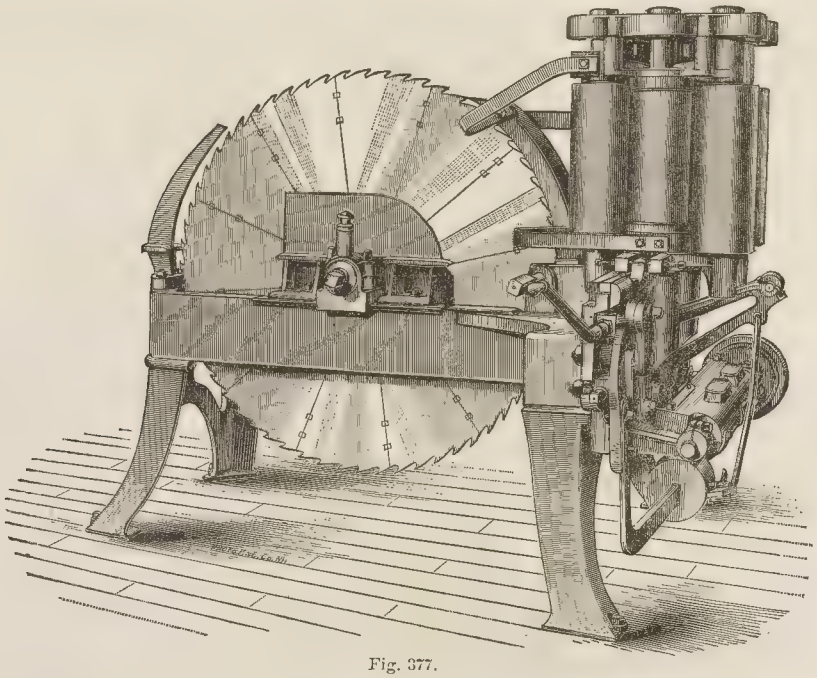


Fig. 377.

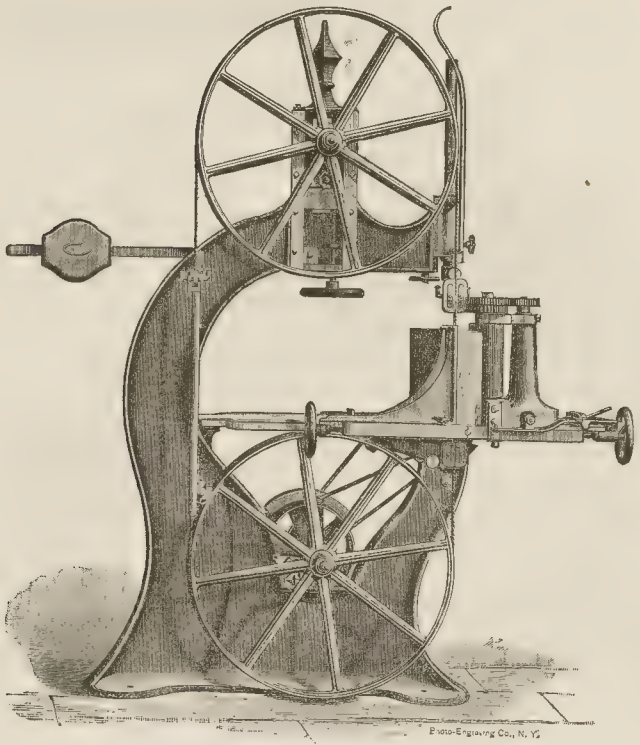


Fig. 378.

in the gauge of the saw-plate, and hence in the width of the kerf. The circular saw at high speeds yields very easily to lateral pressure, and will not cut to true lines when thin unless guided near the cut. Moreover, the guides upon which the rolls yield are placed near their middle points. By this means the pressure upon the stock does not cause a binding upon the slides and guides, which will be caused when the slides are vertical and below the working level. The rolls can easily be set to any required bevel. Instead of being driven from a splined shaft with sliding bevel-gears, the pairs of rolls are driven from fixed spur-gears by universal joints and telescopic shafts. This avoids the wear on the splined shaft due to the leverage which the rolls exert. There are two changes of feed which may be disengaged by the lever at the left if necessary to withdraw the stock for any cause. The arbors are made hollow, to prevent springing.

Fig. 377 shows a segment-saw. The segments are connected together by copper dovetails. While the gauge at the circumference is 16, at the center it is 5. The feed is given to the rolls from a long gun-metal worm, which is driven by round belt from the arbor. The worm-wheels will roll upon the screw for any adjustment laterally, and

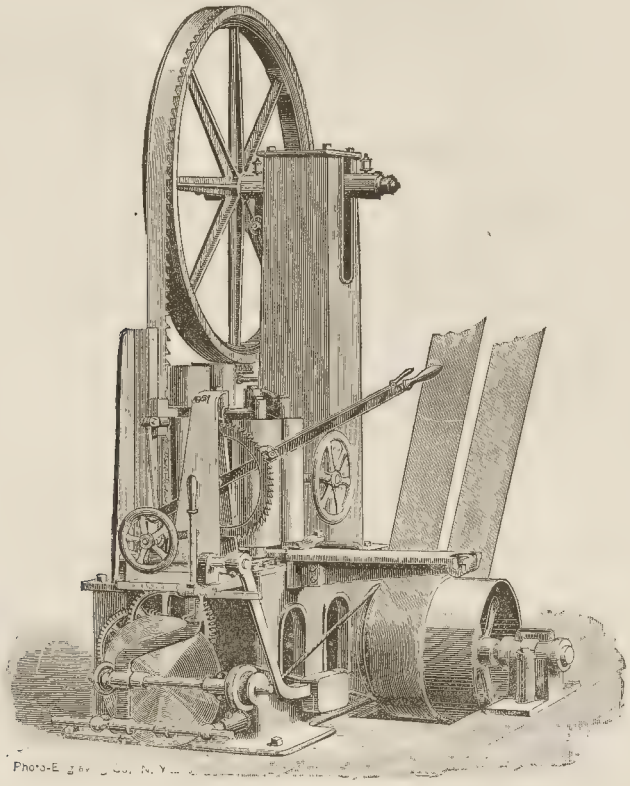


Fig. 379 *a*.

the whole feed works will swivel for bevel sawing. The weighted lever bears upon an equalizer, and the rolls are geared together at the top. The use of the worm simplifies the feed-gear very satisfactorily. Other builders use the segmental saw for their larger sizes, or when preferred by their customers. By the use of the circular saw the feeding speed may vary from 25 or 30 feet to the minute up to 90 feet on narrow lumber. Forty feet per minute would be perhaps an average. A notable economy results from this increase of velocity.

The manifest advantages of the band-saw for other classes of sawing has led some of our advanced builders to adapt it for resawing. These advantages are its great thinness, its variable tension, its linear and continuous motion at the cutting-point, its high speed, the simplicity and rotary motion of its machinery, the easy delivery of dust, the coolness of the blade, and its taper- or wedge-shape.

Fig. 378 shows one of the lighter types of the band resaw. The lumber is pressed against a guide-plate and driven by fluted rolls. For the feed-gear of these resaws the brush-wheel combination is nearly universal. It permits any variation of speed of feed, and reversal is possible. The saw has all the usual attachments of belt-shifter and brake, brush to dust the lower wheel, roller-guide for the passage of the blade to the upper wheel,

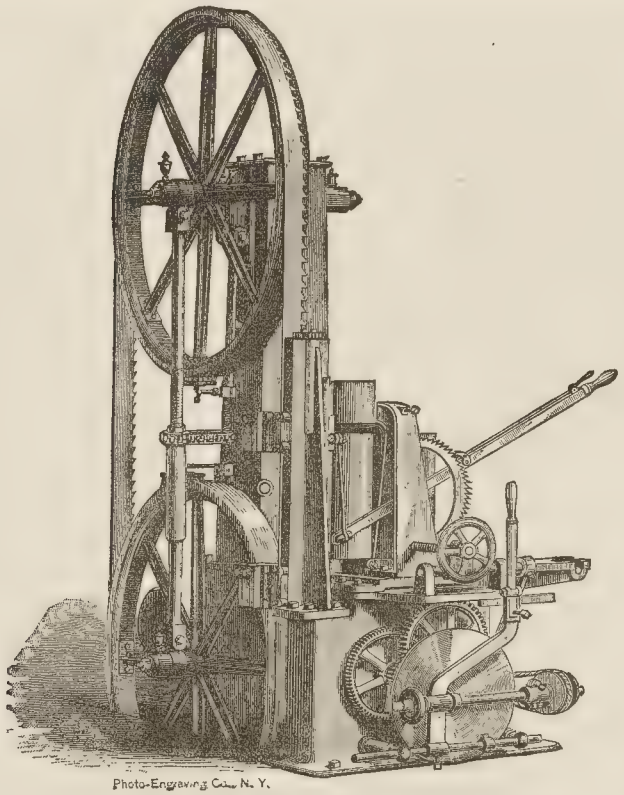


Fig. 379 *b*.

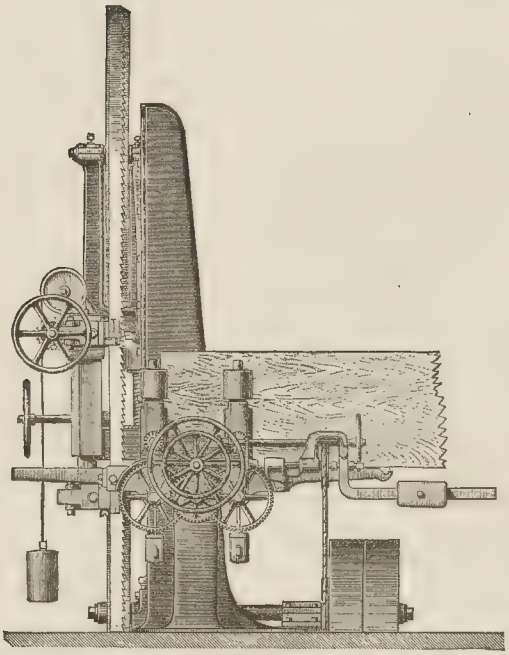


Fig. 380 *a*.

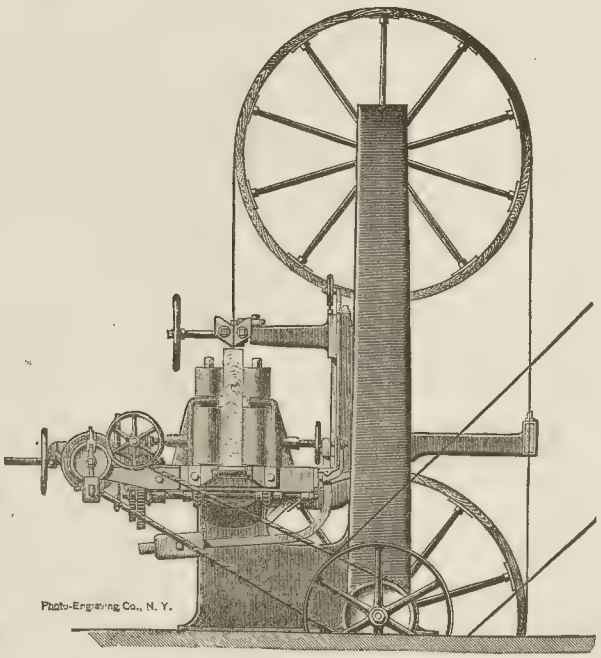


Fig. 380 *b*.

thrust device and lateral guides above and below the cut, and straining device by weight and screw. The upper bearing slides in guided ways, and the arbor of the wheel has a screw adjustment to direct the course of the blade on the upper wheel. In a larger size, carrying a wide blade (Figs. 379 *a* and *b*), the saw-arbor cannot overhang. Therefore a telescopic link, adjustable by screw and chain-gearing, effects the adjustment of the arbor and maintains the tension of the saw. The outer pair of rollers yields by a weighted lever, the feed, as before, being by brush-wheels in front, which are adjustable by the hand-lever. The saw-wheels are of iron, with wooden rims covered with rubber. Special roller devices for the thrust are provided on these larger sizes.

Figs. 380 *a* and *b* show a similar type with the brush-wheels controllable from in front by a screw of steep pitch. The upper guide and thrust-bracket are counter-weighted and adjustable by hand-wheel. The brush-wheel pressure is adjustable by the weighted bent lever. The upper wheel-arbor is supported on both sides of the wheel. The rear feed-rolls yield with a weight to maintain the desired pressure. The band resaw has a variation of speed of feed up to 25 feet per minute. This makes it possible to do over four times as much work as with a reciprocating saw. The band-saw has a capacity for 10,000 feet per day, while the up-and-down saw will finish 2,500. The manifest advantage over the circular resaw is the use of thin blades of 14 or 18 gauge. It is possible to get two boards, sawed and planed, three-eighths of an inch wide, from a 1-inch board. The kerf and planer-chips all come out of one-fourth of an inch. For valuable lumber this is an important consideration, and it is for such materials that the band resaw has found its special application.

§ 38.

DIMENSION-SAWS.

After the lumber has been resawed to the desired thickness the next sawing operation upon it will be its reduction to the desired dimensions, either of width or length. For this purpose two saws will be used, known as the ripping- or slitting-saw, for sawing with the grain, and the cross-cut or cut-off saw for severing the fibers across the grain. For sawing with the grain, the teeth cut upon their front edges. Cross-cut saw teeth cut upon their sides. In ripping, the boards have to be fed against the saw; in cutting off they may be fed to the saw, or the saw may be moved across the work. The choice of these two latter methods will be governed usually by the size and weight of the piece to be sawed.

The usual bench-saw is a solid steel disk, with proper teeth in the circumference and a central hole for the driving-mandrel.

Fig. 381 shows forms of teeth of the two classes of saw. Inserted teeth are not extensively in use for this class of saw. The usual type of mandrel has the pulley at one end and the flange and nut for the saw at the other, the two journal-boxes lying between them and close to the points of strain.

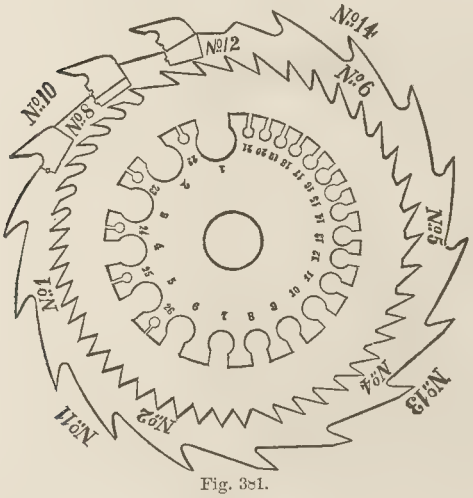


Fig. 381.

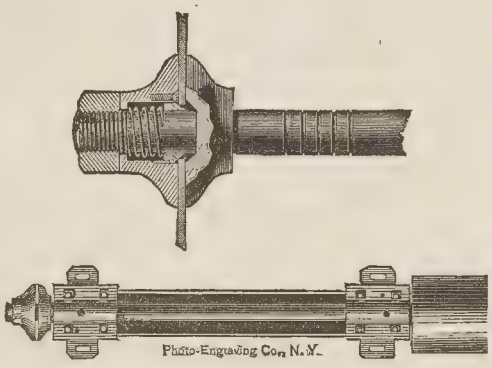


Fig. 382.

Fig. 382 shows a usual type. Most of the boxes are self-oiling to a certain extent, although the wisdom of intermitting the attention of the operator to his boxes has been questioned. A general type of these boxes would show an oil-cellar below the bearing, in which some fibrous material is put, which may hold the oil (Fig. 383). A diagonal groove in the bottom of the box carries the oil upward and to the ends, whence any excess flows back. The chambers at the ends of the box prevent any loss endwise, and a great saving is claimed and effected. The

mandrel shown prevents end-play by a series of rings turned in the journal, into which fit ridges in the babbitt of the box. The same figure illustrates a special cone-bushing, to simplify the centering of a saw whose hole is larger than the mandrel. The spiral spring in a hollow in the outer flange takes up all the play and the flange holds all from moving. A western builder tightens in a cone by a screw in the axis of the arbor. The pulley on the mandrel is made highly crowning to diminish the tendency of the belt to curl up and run off when bending so rapidly over so small a pulley. The pulleys must be small in cross-cut saws especially, in order that the work may pass over them. For this reason, too, the counter-shafts must be below or on the floor. For ripping-saws they may be overhead. The pulley must also be relatively wide. Its face is usually made equal to its diameter.

The saw-tables or saw-benches of to-day are of wood or of iron. The wood tables are made by several builders to supply a demand for a cheap article. The iron frames, however, are standard, as they should be.

Fig. 384 shows a type of wooden bench in which the top is made to lift by means of the cams under the front end. These are worked and held by a worm and wheel.

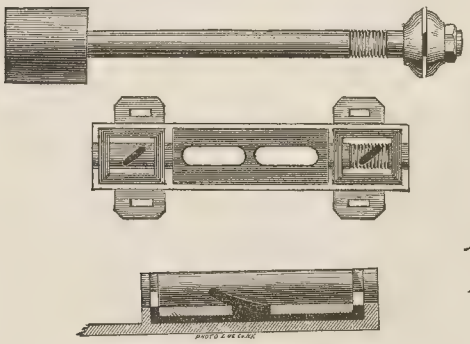


Fig. 383.

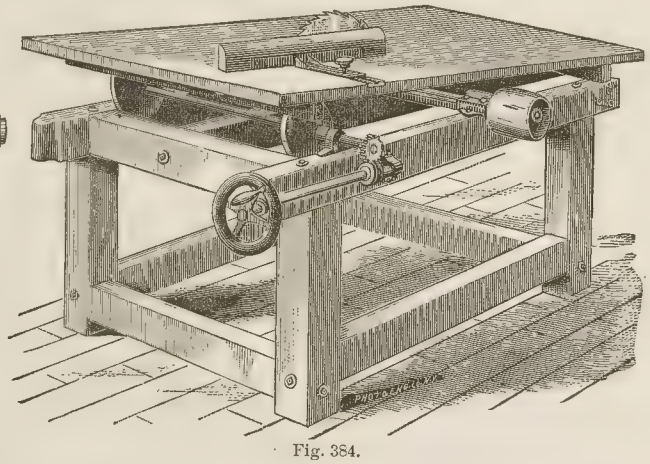


Fig. 384.

Fig. 385 shows an iron bench in which the whole table lifts bodily upon guides by a screw worked by the hand-wheel. One is for heavier and the other for lighter work. The object in varying the projection of the saw above

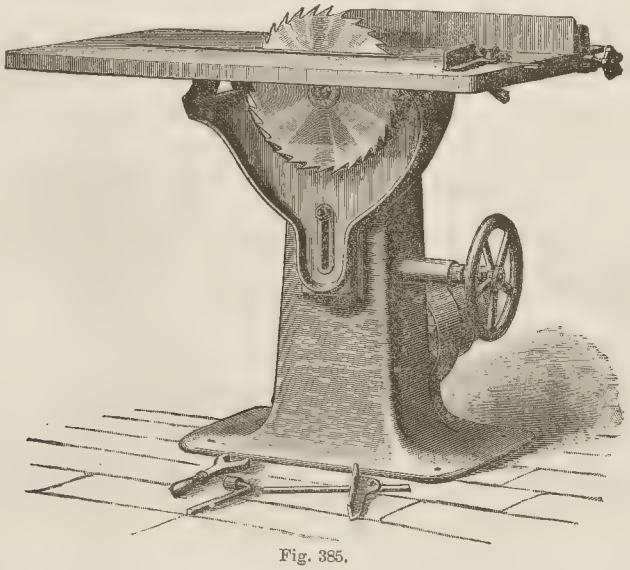


Fig. 385.

the table is to enable it to cut rabbets and tenons, or to make the cuts for gains. The wood is passed over it, and the saw cuts to the gauge mark. Round grooves may be cut in the face of work by passing it obliquely over the

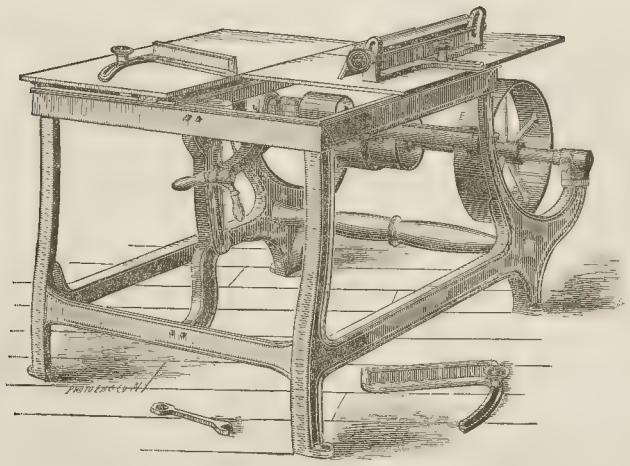


Fig. 386.

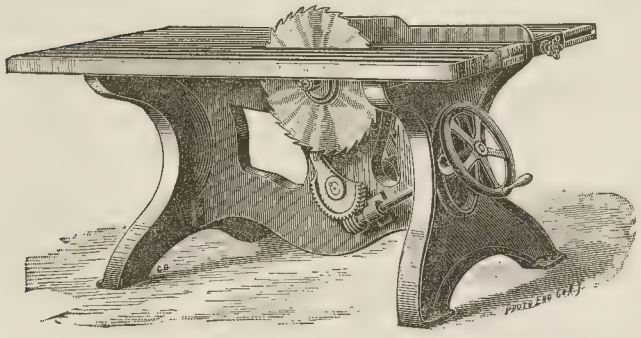


Fig. 387.

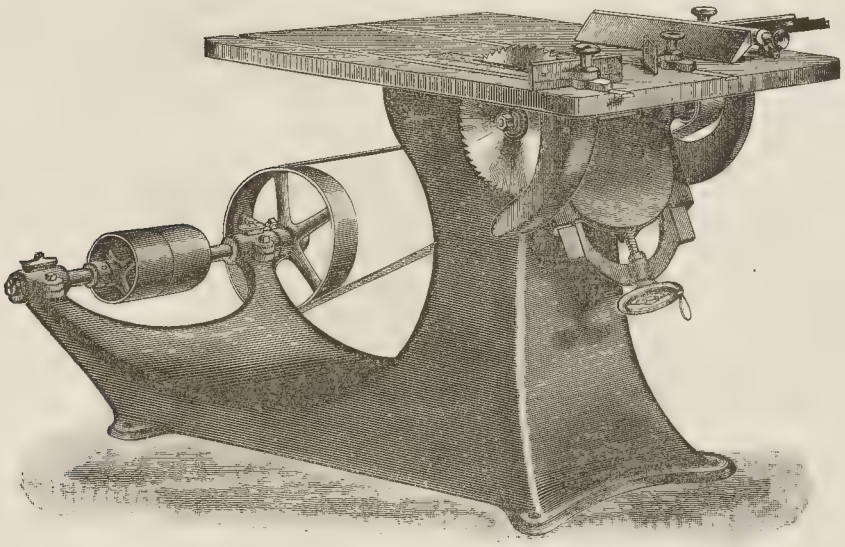


Fig. 388.

top of the slightly-projecting saw. All the best benches, therefore, of to-day have this adjustment, either lifting the table as above or by raising the saw-mandrel. In Fig. 386 the mandrel boxes are carried on a frame whose center of oscillation is the center of the counter-shaft. The arm and handle which raises and lowers the frame is clamped at any point of the slotted sector. In Fig. 387 the mandrel is controlled by the worm- and segment-wheel, and in Fig. 388 by the screw directly. These also illustrate the differences in design. The most modern practice approves the use of one single casting, by which stiffness is secured, and fewer joints in the frame.

For guiding work to the saw various arrangements of fence or rest are used. For iron tables a form such as shown in Fig. 389 has been used for splitting. The fence proper slides in the grooves of the rear part, which may

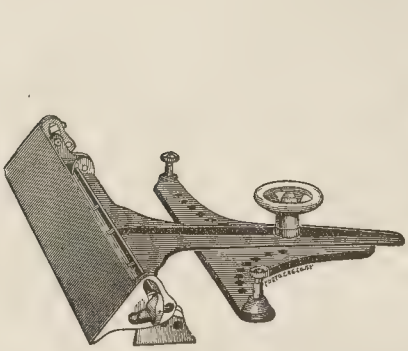


Fig. 389.

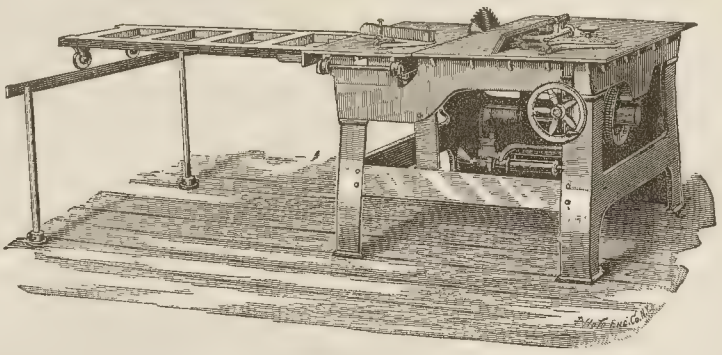


Fig. 390.

be pinned in holes in the table, so as to be parallel to the saw and at any desired distance from it. The fence can be clamped at any vertical angle with the plane of the saw for sawing bevels. In order to feed for cross-cutting a guide will be clamped at the desired horizontal angle with the saw and moved forward against the saw. The

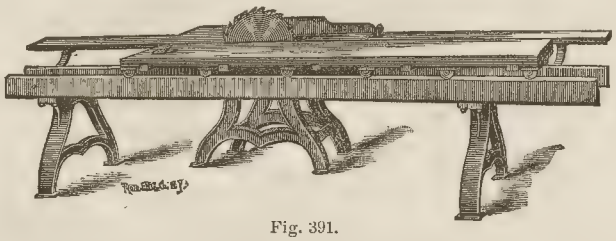


Fig. 391.

motion of the guide will be made parallel to the plane of the saw by a groove in the top of the table, in which fits a tenon on the bottom of the guide, or else (Fig. 390) the half of the table is made to slide upon ways with the guide

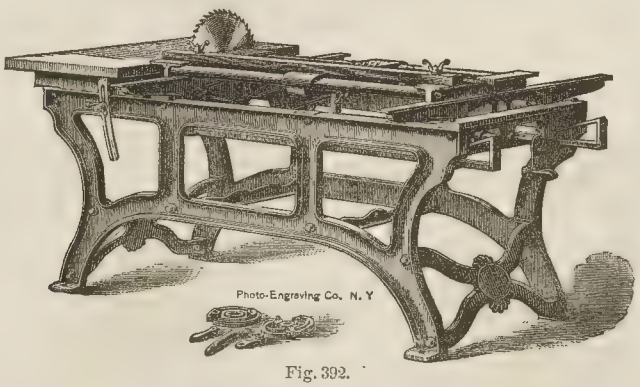


Fig. 392.

clamped upon it. The former method is usual upon tables with wood top, an iron groove being let into the top for the purpose.

Fig. 391 illustrates a roller-table for slitting-benches, designed for heavy plank, and Fig. 392 shows a table for



Fig. 393.

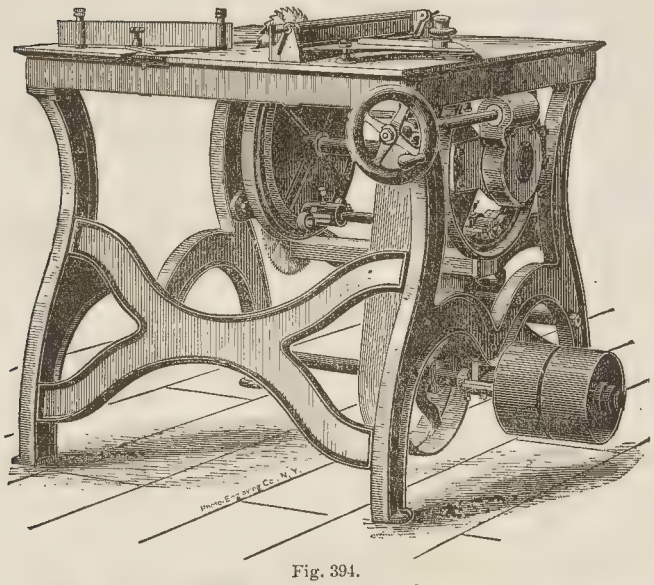


Fig. 394.

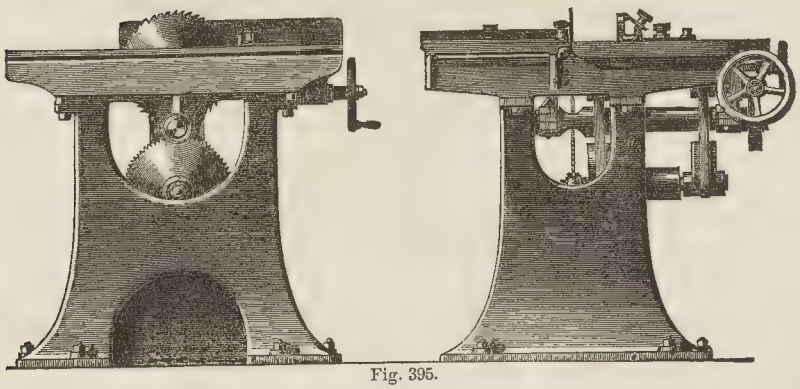


Fig. 395.

cutting off only. In this form the fixed half of the table may be inclined for bevels and the ways for the carriage may be lifted together by inclined planes for cutting across for tenons and gains. The crank at the right controls the inclines.

A very great part of the saw-benches for job or miscellaneous shops is made double, to accommodate at once a ripping and a cut-off saw.

Fig. 393 shows a double bench with adjustable saws, swinging in separate frames around the counter-shaft. There is a device to prevent both saws from being above the table at once, which is an element of danger. Its action can be suspended, however, if necessary. A more usual type of double table is illustrated by Fig. 394. The two mandrels are borne on opposite ends of a diameter in a frame, which receives a motion for adjustment around its center by a worm and wheel. Either saw may, therefore, be lifted up through the slit in the table and to any desired amount. It is a specialty of one or two to have the boxes of the mandrels remain right side up in all positions of either to avoid loss of oil. The driving-belt is made extra wide, and is guided so as to be in contact with that pulley which is in use in its every position.

Fig. 390 shows a similar design, and Fig. 395 illustrates a high-grade machine, built with great care and exactness for pattern-shops and the similar grades of service. The ripping-fence is adjusted by screw- and hand-wheel, and the other side of the table slides upon V's. The counter-shaft is at the base of the machine, so that the top is entirely free.

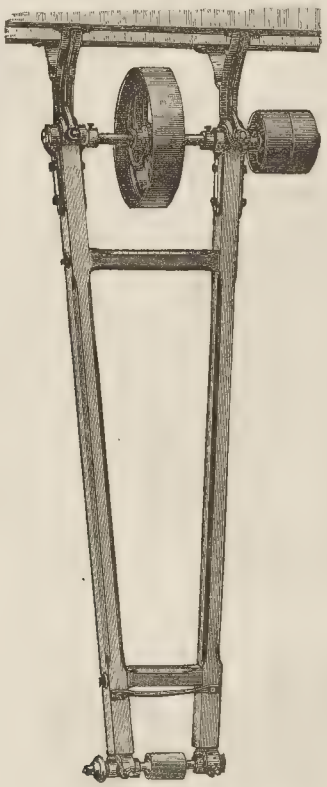


Fig. 396.

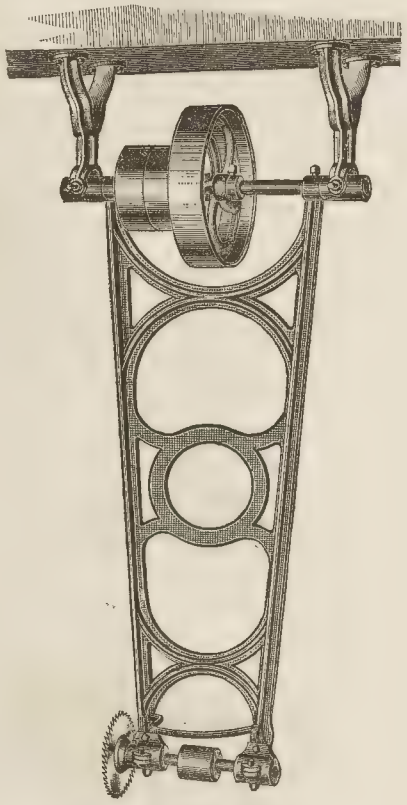


Fig. 397.

The other class of cross-cut saw-benches, where the work is stationary and the saw is fed toward it, is especially adapted for heavy work, or for work which, from its shape, would not rest stably against guides if the latter were in motion. The table for this class of saw is entirely separate from the frame of the tool itself. These saws appear in two forms. The cheaper and less exact is known as the swing cut-off saw, and appears in Figs. 396, 397, and 398. Fig. 396 shows the older form of wood frame, Fig. 397 is the improved iron frame, and Fig. 398 illustrates a shielded saw of neat design. The saw is borne on what is often called a yoke mandrel, receiving its motion from the counter-shaft, round which the frame swings. In the best practice the frame swings around the outside of the boxes of the hangers, so as not to bind the shaft. These may be arranged to hang from overhead or to come up through the table from below.

The better class of traveling saws is known as the railway cutting-off saw (Fig. 399). The saw-mandrel is borne

on a carriage, gibbed upon ways. The belt passes over guide-pulleys on a frame centered on the counter-shaft. This frame is linked to the carriage, and they move forward together. The driving is done by the under belt, and

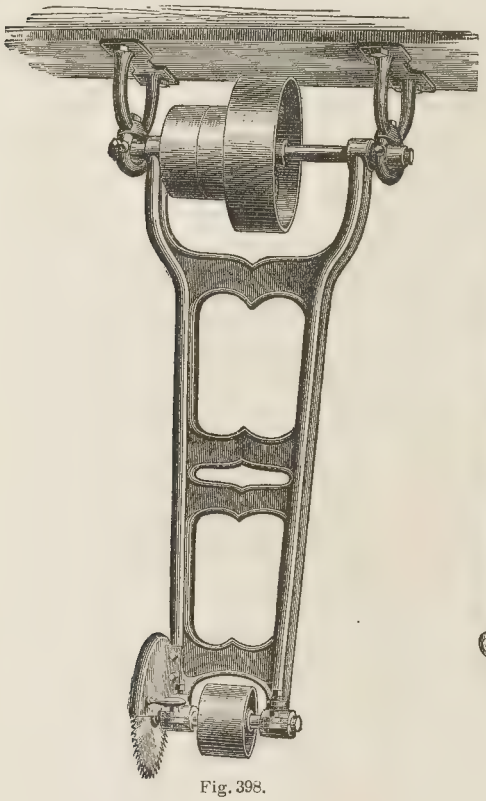


Fig. 398.

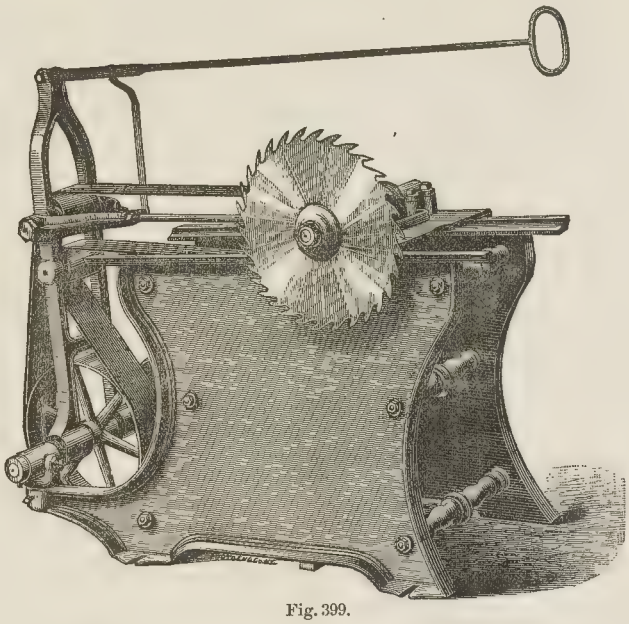


Fig. 399.

no difference is made in the strain of the belt within the limits of the travel of the saw. One maker links the frame to a pendulum in the way-frame, whose bob acts to retract the saw when the handle is released. The handle is always kept horizontal by the short link.

Fig. 400 shows a bracket railway-saw hung from a wall. The counter-shaft is overhead, over the center of the traverse of the saw. The bracket is mounted on a true plate, permitting adjustment for diminished diameter of

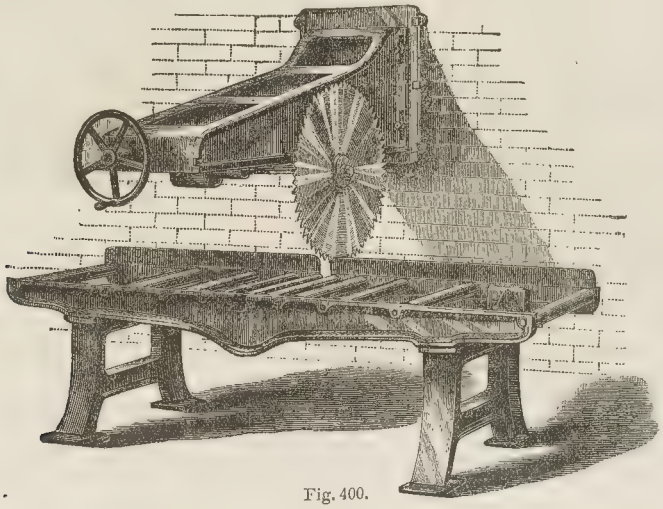


Fig. 400.

saw. The table has friction-rolls for the easy motion of heavy timbers. Not infrequently the tables are fitted with a scale of length from the saw-kerf as a zero-point, for convenience in cutting to dimensions.

There are devices upon the tables of several builders by which the adjustment of the ways of sliding tops is possible. This renders it easy to adjust to parallelism with the saw. Moreover, a tonguing or grooving head can be placed upon the saw-mandrel, where it may not be convenient to perform that operation on a special machine. Again, some table tops are arranged to tilt sidewise as a whole, for sawing bevels, and there may be minor modifications which are not of sufficient prominence to rank the table as a special machine.

§ 39

SPECIAL FORMS.

The circular-saw table may be adapted for one line of manufacture by very simple additions. It may be applied for cutting shingles from one or several blocks by adding a carriage, which shall reciprocate and give alternately unequal feeds to the ends of the blocks. It may be used for sawing to the center of small logs for clap-boards or to prepare the stock for ax-handle lathes and the like. The log is held on centers and rotated by an index-plate after each cut. A small core will be left, which can be used for other purposes. For cutting up cord-wood for railroad purposes a saw with a long mandrel is used, with a heavy solid balance-wheel near the pulley end. This is to store up work in the intermissions of cutting, so as to relieve the driving-power, which is very often a horse-tread power. For lath, fence, or flooring manufacture, or for general edging, a gang of saws may be used. For smaller work of standard thickness the saws may be spaced by distance-collars. These should be of a diameter sufficient to support the work at the level of the table. For miscellaneous edging, the saws are often upon grooved sleeves, which can be adjusted laterally on the splined or squared mandrel from the feeding-end. Very often these gang-edgers are arranged to be self-feeding. A serrated roller drives the solid wood in front of the saw, and a smooth pressure-bar holds the pieces from flying behind the cut. This may be also applied to a single slitting-saw. Two saws may be run on a single mandrel, for cutting off all pieces to a standard length, or the two saws may be on mandrels at an angle with each other, for producing a standard bevel at both ends of work. For sawing circular arcs from the plank two dished saws suitably spaced may be used. For sawing staves for barrels, either with or without bilge, cylinder saws are used. The block is fed and retracted from the saw on the proper lines automatically, while the staves are cut to the proper curvature. By setting a plain circular saw, of thick gauge, obliquely on its mandrel, it may be made to produce square grooves with considerable range of width.

Fig. 401 shows the use of oblique washers for this purpose, and Fig. 402 shows a different device. The latter may be adjusted very rapidly while the saw is in motion. The circular saw may also act as cutter for producing

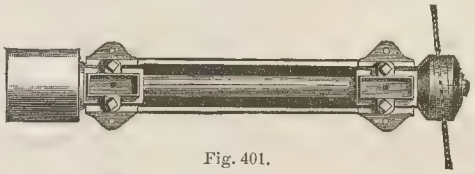


Fig. 401.

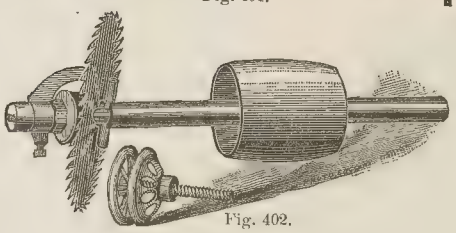


Fig. 402.

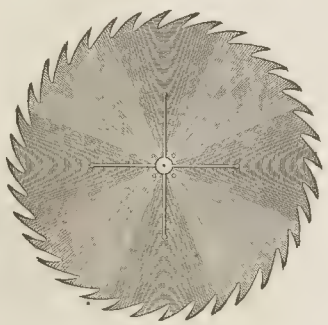


Fig. 403.

surfaces of revolution upon work revolved in front of it. When thickened or made of especial profile it may be applied as a kind of milling-cutter, for such duties as crozing barrel-staves and similar service. The great number of cutting-edges permits the saw to work very rapidly.

With regard to the manufacture of saws, the majority are made by the old process. The teeth are punched from the disks of soft steel, which are then hardened and tempered, and are then peined true with hammer on anvil. There is a New England manufacturer who claims advantages from his process of bringing the saws to form by pressure and heat under patented machinery. A western builder aims to avoid the difficulties of expansion and contraction by heat in service by radial slots in the plate (Fig. 403). These slots close when the blade tends to expand, and thereby the buckling and "wobbling" of the plate is asserted to be diminished. Bench-saws rarely use inserted teeth. They are employed more for forest practice.

§ 40.

BAND-SAWS.

The band-saw in its smaller sizes is not much used for dimension-sawing. While it can be so applied, it is for curved sawing that it meets its widest adaptation. Log-sawing and resawing are done with wide blades; scroll-sawing requires the use of narrow and thin blades. Of course the advantage of the band-saw over the jig or reciprocating saw is its continuous motion. This makes the presentation of work more easy and accurate, and the dust is carried down away from the lines of the marking. The advantages of the principle of the band-saw have already been noted.

The frame for the shop band-saw is now most frequently in one piece, cast in the form of a letter G, with cored or hollow section. In a few the arm carrying the upper guide is bolted on. The belt-wheels are of cast iron, or are built up of wrought-iron spokes and wooden rim, or are of composite design. Very often the two wheels are of different designs. The lower wheel is the driving-wheel, and may be made heavy, since its inertia can do no harm to the saw. The upper wheel, however, is an idle-wheel for maintaining the tension of the saw, and should be as

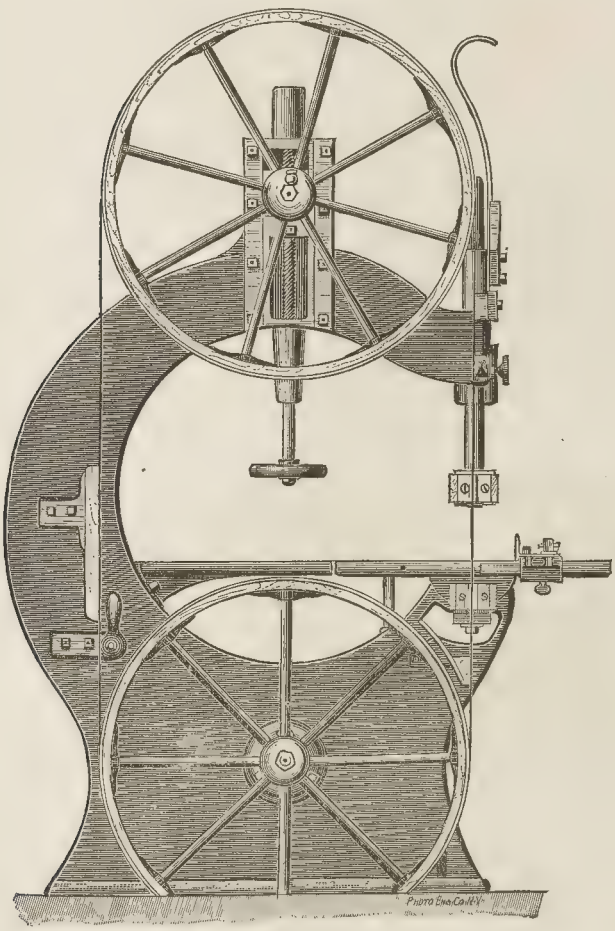


Fig. 404 *a*.

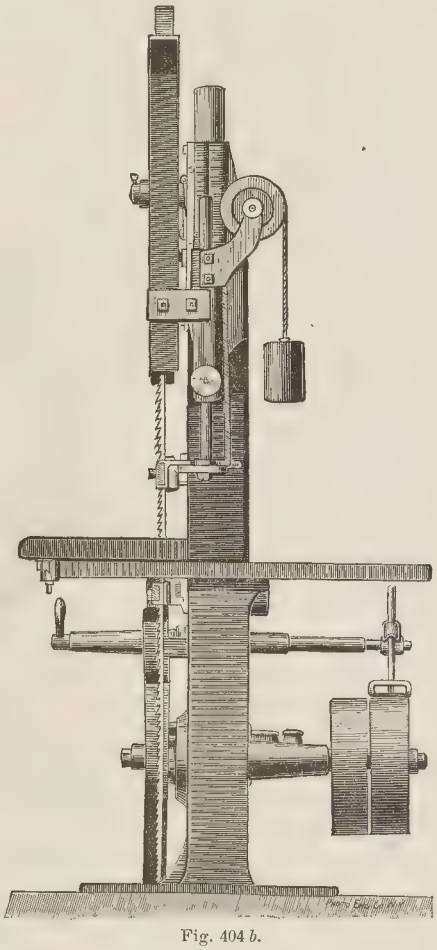


Fig. 404 *b*.

light as possible. The reason for this lessening of inertia and living force in the upper wheel is very obvious. When the lower wheel is started by shifting the belt upon the fast pulley the saw at once tends to start at full speed with it. In putting the upper wheel in motion the saw will be stretched and will slip over the upper wheel till its inertia is overcome. The greater its dead weight the more the slip. When the belt is shifted off the fast pulley, the friction on the lower shaft, due to the strain of the belt on the loose pulley, will arrest the motion. The

upper wheel having less friction would be likely to overrun the saw, straining it or slipping under it. The tendency to overrun would also occur when the work of the saw grew harder and it moved more slowly for a time. The slipping of the saw or wheel tends to heat the saw and ultimately to deteriorate it or to wear the covering of the wheels. For these reasons special features of upper wheel will be noted. The saw is strained by the adjustment of the upper wheel. Its bearings are borne in a slide which rises and falls on a screw. This permits a variation in length of the saw of several inches. For maintaining the tension of the saw under slight variations of length, due to stretch or temperature, a weight or spring is applied to the adjusting-screw. The weighted lever is most approved, being easily adjustable and positive. Rubber springs are apt to become stiff by cold and by long service. To guide the saw upon any part of the face of the upper wheel the mandrel is made to tilt. This is usually done by a hinging apron lifted by a set-screw. Some of those in which the plane of the guides is at right angles to the way in which they stand in Fig. 404 had the adjustment for the plane of the wheel in a horizontal plane. The former is approved, however. The wheels are covered with leather or rubber, to preserve the set of the teeth of the saw. Another very essential feature in the shop band-saw is the guide and thrust device at the cut. This must prevent the saw from twisting on curves and from yielding to the pressure of the cut.

Figs. 404 *a* and *b* show a saw strained by screw and spring. The top guide is counter-weighted and clamped close to the cut. The lower guide is just below the table. In this tool the thrust is taken by a steel washer set forward by a cylinder of cast iron for blades of different widths. The washer may be rotated as it wears. The side guides are adjustable for different thicknesses and confine the washer.

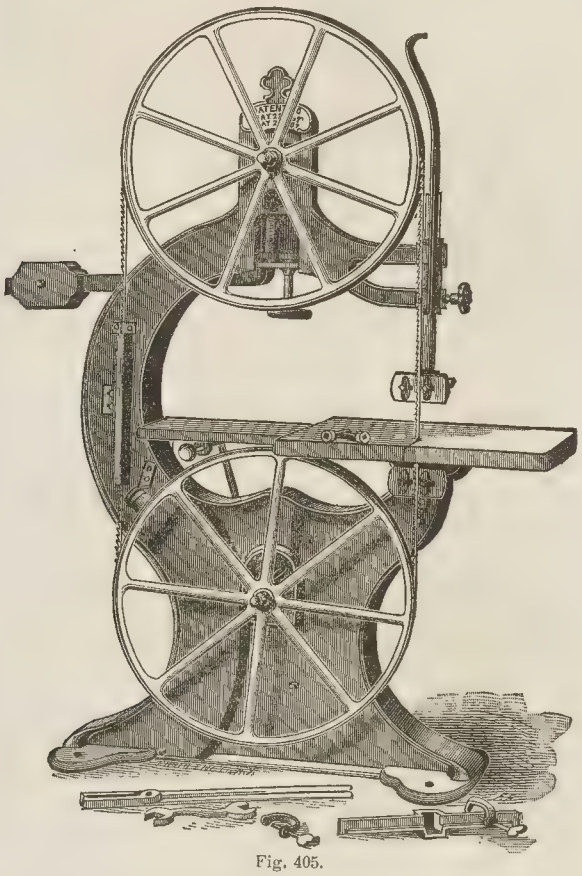


Fig. 405.

Fig. 405 shows the arrangement for straining the saw by a weight. The thrust is here borne by a steel plate, which is adjusted by four set-screws, so as to have a true bearing against the blade. The side guides are of wood. A brush keeps the sawdust from adhering to the rubber tire.

Fig. 406 has a weighted lever to strain the saw, which has a stop so that the tension may be taken off when not required. The thrust is here taken by a steel rod in place endwise behind the saw. It is adjusted by a milled head behind the guide bar. Side guides are of wood. This tool has a guard, C, below the table to carry off blocks and dust from the saw.

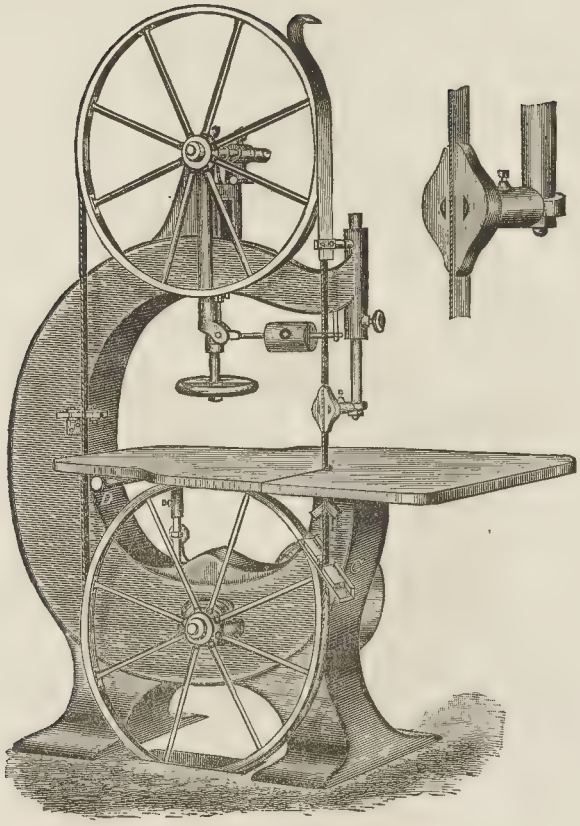


Fig. 406.

Fig. 407 illustrates a design with cast-iron driving-wheel below and an elastic steel wheel of very light construction above. A similar weighted lever takes up and compensates for any buckling or stretch of the blade, and the thrust is borne upon a steel roller with wooden side guides. The roller device diminishes the tendency for the back of the saw to upset or harden. The objections to it are its high speed of rotation, and that the support to the blade must be at a point above the cut distant at least the radius of the roller. This roller is also apt to "ring" or become cut into grooves. There is a roller at the rear to guide the blade to the upper wheel, and the ascending part of the blade is shielded. The guard in front of the upper wheel is universal in order to prevent injury in case of accident. The roller thrusts are lubricated by self-oilers. There is a brake connected to the shipping device to arrest the motion quickly. The rubber tire of the wheel is ground true in place.

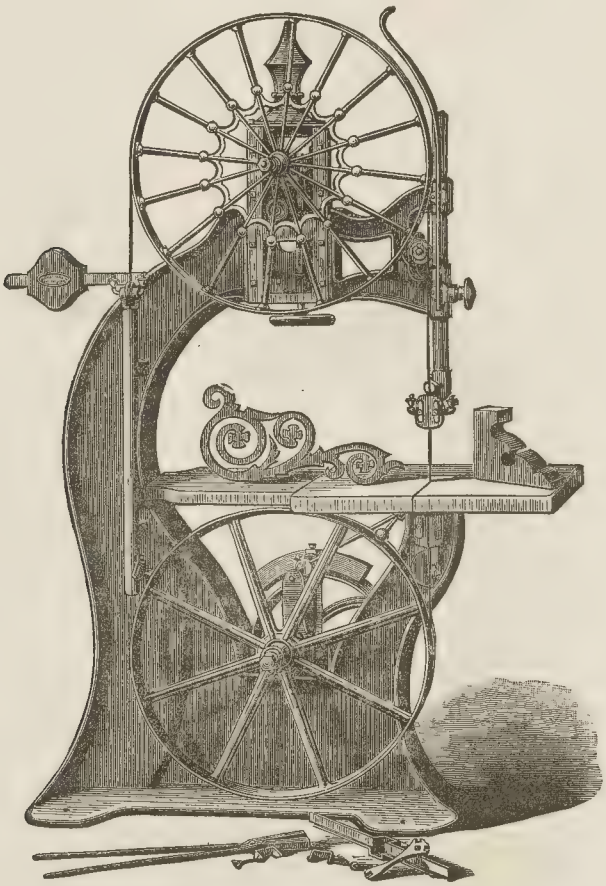


Fig. 407.

Fig. 408 has the mandrels supported in boxes upon their ends, instead of permitting the wheels to overhang. The counter-weight acts directly in the plane of the saw, so that its action does not bind the slide, and therefore it is more sensitive. The thrust is taken by a hardened steel disk whose center is out of the plane of the pressure against the saw. The grooves cut by the back of the saw do not intersect at one point, and the washer can be turned to present a fresh surface until it is all used up. The rotation is by a worm-thread cut on the edge of the disk.

Fig. 409 illustrates a type of slightly different shape of frame. The adjusting-apron swings laterally by set-screws to produce vertical adjustment of the upper wheel. The geared tension-screw is counter-weighted. The lateral guides are of wood. The thrust of the cut is taken upon a series of balls of hardened steel. These rest in a drilled vertical cylinder, and are kept from contact with each other by steel-drilled washers of the same diameter. The balls are set up against the saw back by set-screws, whose points bear against the balls a little at one side of the line of saw pressure. As the balls are turned by the saw a compound motion is caused by the bearing of the screws, and therefore the balls are prevented from "ringing". This ball system distributes the pressure against

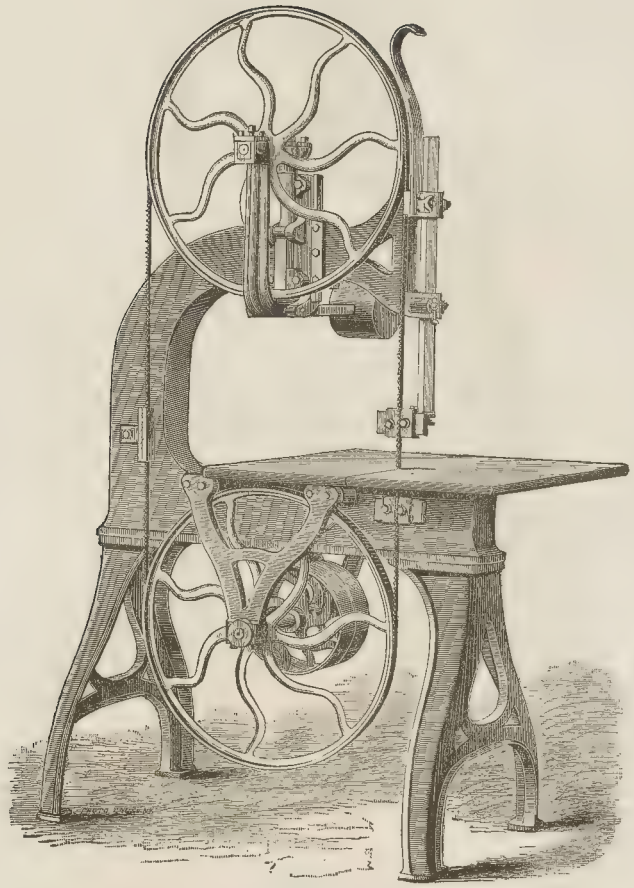


Fig. 408.

the blade over a large area and brings the first resistance close to the cut. To counteract the strains on the saw, due to starting the upper wheel and to its overrunning when the lower wheel is stopped by a friction-brake, this machine has a special device. The rim of the upper wheel is flanged, and pockets of anti-friction alloy are formed in recesses in it. In the groove thus formed a steel ring covered with leather is accurately fitted. The saw lies upon this ring, the leather serving to protect the set of the saw. This light ring will slip in the groove at the start

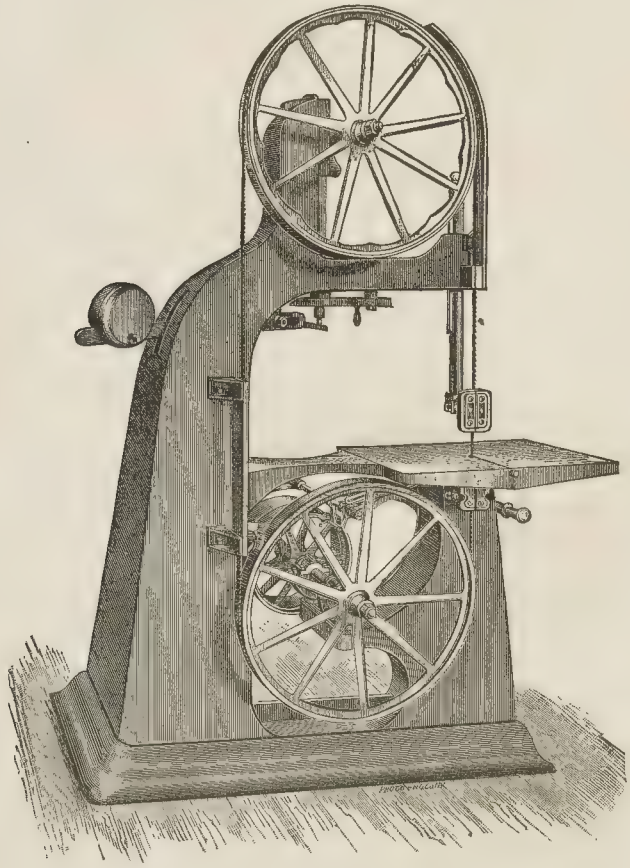


Fig. 409.

or the arrest of motion and distribute the shock of change over several inches of circumference and between smooth surfaces. Otherwise the saw-teeth must rough up the covering of the wheels. The centrifugal expansion of the ring gives elasticity to the bedding of the saw. The friction-brake clasps the pulley-face on both sides and stops rotation rapidly without forcing the wheel out of line. The links to the brake from the shifter-lever are so arranged that the saw is not liable to be freed accidentally and to be started while the operator is handling it. The brake-lever will have passed its dead-point, and will be so held locked by the bearing of the shifter-rod when the brake is acting and the belt is on the loose pulley. The chattering of the shifter-fork cannot disengage either shifter or brake.

There is a variety of cheaper designs with omission of the special features of excellence in the larger patterns. The strain on the saw may be by screw only, without spring or weight; the thrust may be by wood only; the table may be fixed without arrangements for bevel sawing, and less care may be taken in fitting. These are in answer to a demand for low-priced goods, where durability and accuracy are thought of less moment.

§ 41.

RECIPROCATING SCROLL- OR JIG-SAWS.

A continuous saw is not adapted for fret-work, in which internal patterns are to be cut out. It becomes necessary to have a saw of which one end may be inserted within the area to be removed. The band-saw must therefore be supplemented or replaced by a reciprocating saw, which shall have one end which may be freed from the driving mechanism. These saws appear in three forms: Gate-saws, strained saws, and unstrained saws. The gate-saws are adapted for scroll-work upon heavy plank. The saw is strained positively by a screw between an upper and lower frame, which receives motion from a wrist-plate shaft. There may be one saw, as in Fig. 410, in the center of a wide table, or the post-gate system of Fig. 411 may be duplicated upon the other side of the post. Each saw in this case resists the strain of the other. The thrust and twist of the cut is resisted by an adjustable guide, hung from the stationary frame. This also holds down the work on the up-strokes. A reciprocating air-pump blows the lifted dust from the lines in Fig. 410. Centrifugal blowers are more usual.

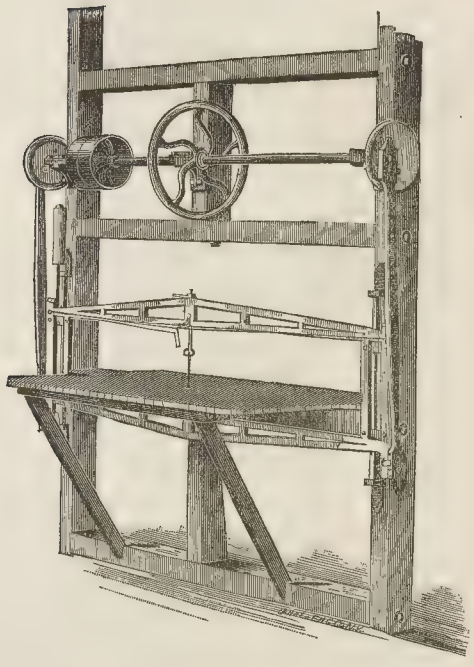


Fig. 410.

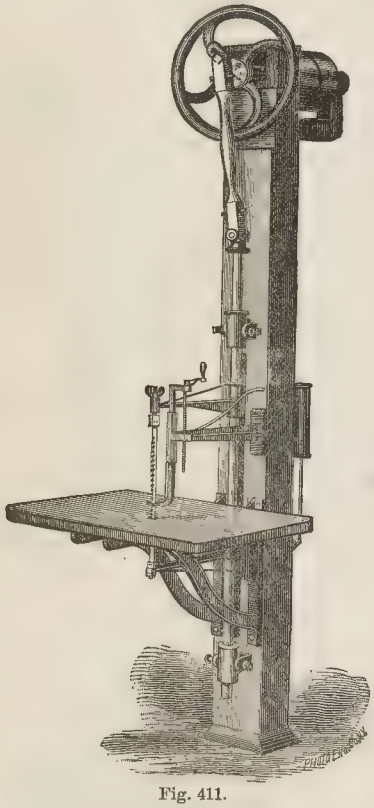


Fig. 411.

In Fig. 410 the trussed frame is so long as to require light lateral bracing. In the post-gate system the central connection makes this unnecessary. In the form shown the slide is of gas-pipe, for the sake of the lightness. The fly-wheel equalizes the work upon the two strokes.

The saws strained with a spring are by far the most numerous. Since they cannot be forced to heavy cuts as in the gate-saws, they must acquire their capacity by very high speeds. The reciprocating parts are therefore made very light, and the spring is made strong enough to carry up the saw, which cuts on the down-stroke only. The great advantage which this type has over the gate-saws is its wide swing. The upper works above the saw are attached to a hanging post, braced by rods to the ceiling. These tie-rods are usually made adjustable by turn-buckles or right-and-left sleeves, which may make the post entirely rigid and insure that the saw is perpendicular to the table. The lower end of the saw is guided by a cross-head, which is driven by a light wooden pitman from a wrist-plate shaft near the floor. This shaft carries a fast-and-loose pulley, the shifter, in many modern designs,

being worked by the foot of the operator. Almost universally the shifter device applies and releases a brake upon the edge of the wrist-plate. A great saving of time results from this. The wrist-plate is made heavy to serve as balance-wheel.

The old form of spring to lift the saw was a bar of ash secured at the end farthest from the saw. This wood spring, when used to-day, is either made duplex or else acts on the saw through leverages. Either system reduces the length and inertia of the spring and permits a higher speed of reciprocation. The problem of straining devices of to-day is to secure equal tension of the saw at all points of its stroke. A large number of designs use the fusee principle, by which the leverage of the saw diminishes as the strain on the spring grows greater. The leather strap to the saw or to the spring is wrapped and unwrapped spirally upon a cone or an eccentric-wheel or arc. Very many are content to attain this object, and permit very high speeds by permitting but small motion to the spring.

In Fig. 412 a spiral spring acts upon the pivoted arc, upon whose face is stretched the flexible band to which the saw is hooked. The arc keeps the pull on the upper cross-head vertical.

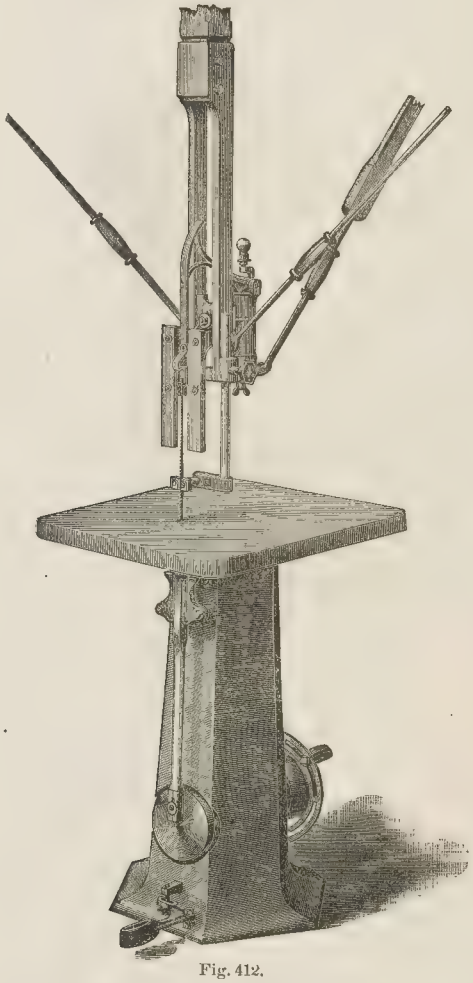


Fig. 412.

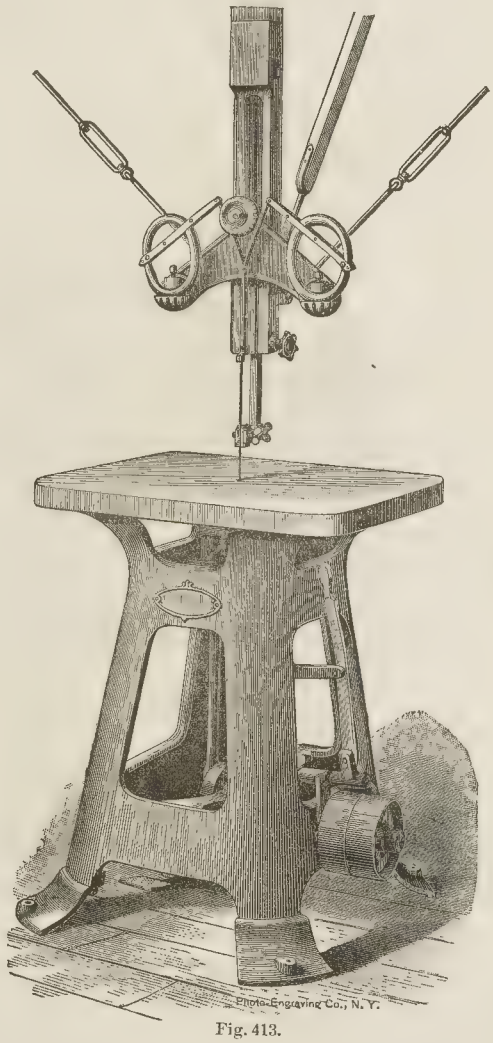


Fig. 413.

In Fig. 413 of a tool by the same builders, the springs are open ovals of thick steel, strained by the levers shown. Their varying leverage equates the varying strain on the springs. Differences of tension are secured by the position of the ovals under the clamping set-screws, and the whole upper casting is also movable for further adjustment. Direct torsion of steel bars is also applied by some designers. The form of table is also adapted to absorb its own vibrations instead of transmitting them to the flooring. So important a consideration is this of absorbing vibrations properly, that some of the older forms should not be put on the upper floors of high buildings.

In Fig. 414 the strain is maintained by leaf springs acting on a differential-wheel device within the shield. The springs may be equalized by the milled-head screws. The shifter-brake acts by an incline and is very powerful. Such a machine may be run at from 1,600 to 1,800 revolutions per minute.

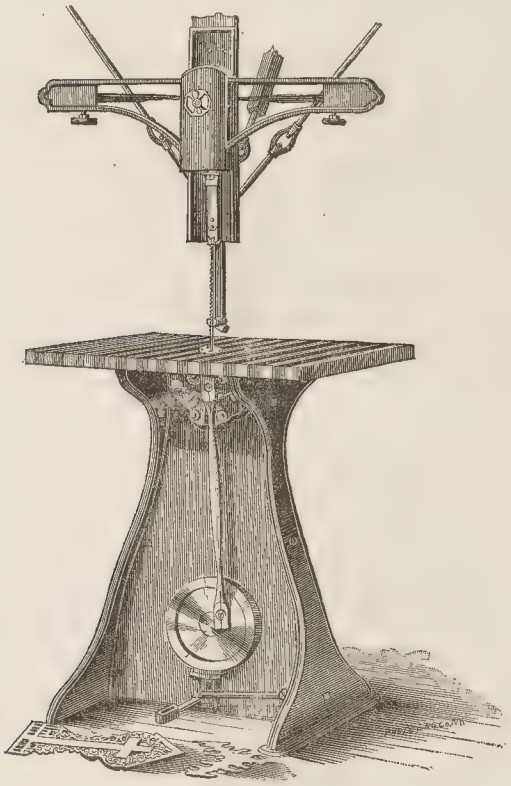


Fig. 414.

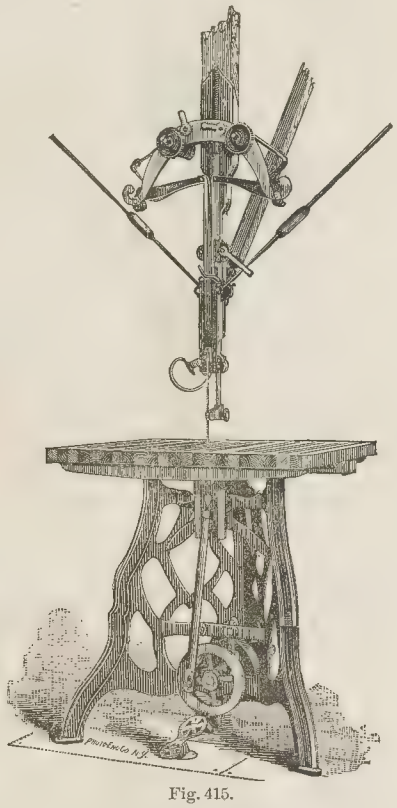


Fig. 415.

Fig. 415 shows a coiled-spring lever-strain, with the strain on the saw adjustable between the limits of 10 to 75 pounds. All the upper works are carried by the pipe E, and they are balanced by the spiral spring O above them. The shaft E is clamped at will by the cam-lever F. The air-pump is within E. The lower cross-head has special devices to prevent jamming or rattling from heat or contraction, and the friction devices for the crank-shaft permit the machine to be stopped, the saw to be removed, replaced and in operation within four seconds. The tilting of the table of a larger size is sometimes convenient for sawing patterns with draught.

Fig. 416 shows a saw in which the straining-lever floats upon the links to the two straining-springs. The relative variation in the leverages of the two springs keeps a uniform tension on the blade. The degree of strain is controlled by the thumb-screw.

Fig. 417 shows a form of unstrained saw on the mulay principle. The slide below is octagonal and hollow, and the saw is pinned to it by spring cotters. The upper end is free, and the thrust is received and the blade is guided just above the work. The guide also acts as a "hold-down" for the work. The fan-blower is above the foot-socket of the hanging post. Such saws may run very rapidly, and avoid the inconvenience of the overhead springs and their wear and fracture. Perforated work is also done very rapidly where no disconnection is required. They will cut quite heavy pieces for carriage, wagon, and miscellaneous work. The strained fret-saws of the same builder are so arranged that the rake of the cut may be varied by throwing forward the cross-head guides. Wooden tops are often fitted with an iron plate around the saw, that a hollow place may not be worn there. Wooden tables are often made of ash and walnut or cherry glued in alternate strips, to prevent a tendency to warp. Most builders have patterns for tables which may tilt for bevels.

There is an infinity of jig-saw attachments to be put upon lathes. These are for amateurs entirely, and for pleasure rather than for profit. They do not come within the scope of this discussion. Neither do the reciprocating saws for forest sawing. They are discussed elsewhere.

In concluding the subject of the reciprocating saws, it may be said that their importance has been waning

since the introduction of the band-saw for outside work and of friezing or shaping cutters for inside ornamentation. The latter finish the surface as well as shape it, and for many classes of work are superseding the scroll- and fret-saw. The latter must, however, be still employed until the type of ornamentation for certain work shall undergo a considerable change.

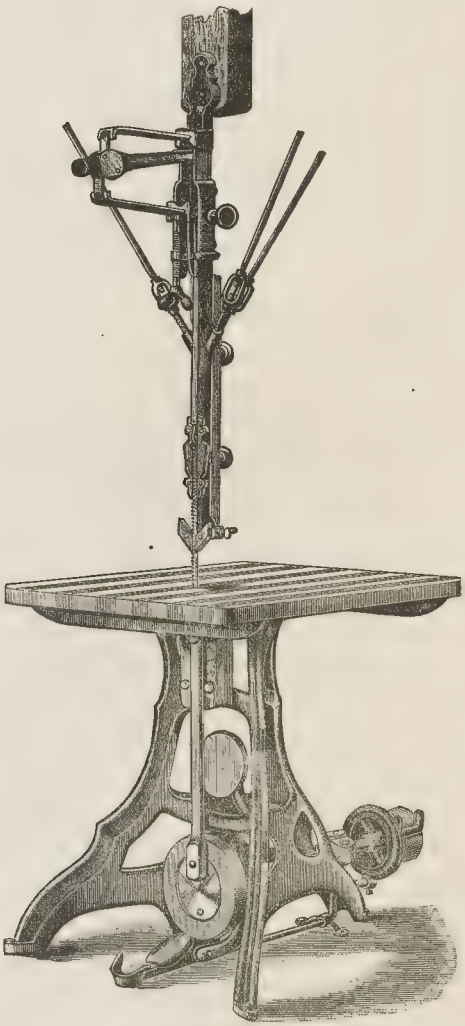


Fig. 416.

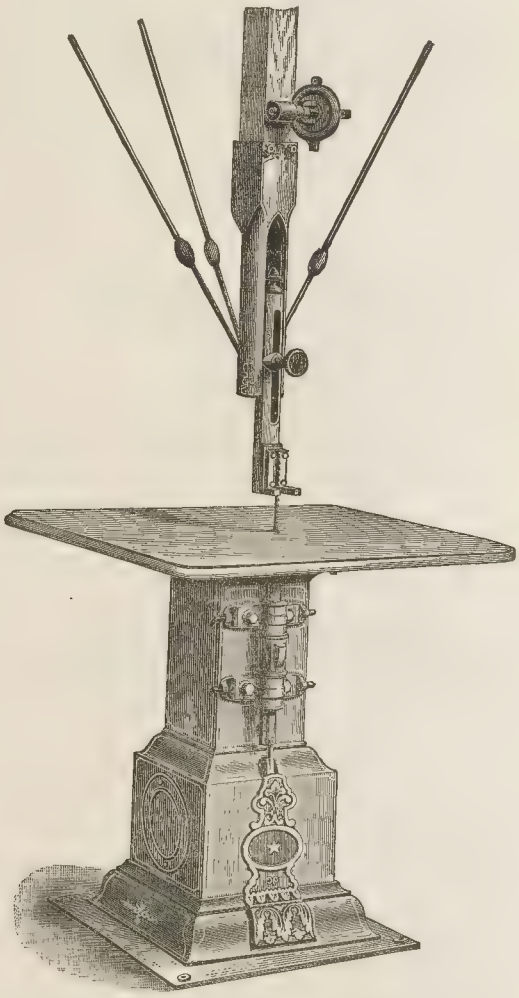


Fig. 417.

Sawing machinery as a class is fundamental to the other processes. Considerable thought has been expended in improving it, and the results are to be seen in the types illustrated. The improvement since the earlier days is very marked, and is daily advancing.

§ 42.

G.—TOOLS ACTING BY PARING.

SURFACERS, PLANERS, AND MATCHERS.

After the wood has come from the resaws, or from the forest-saws, its surface is rough. It will have the marks of the saws upon it, it may be gritty and disfigured, and it may be in wind or out of truth. It is therefore passed through a machine, in which cutters act upon it in the direction of its fibers or grain. The edges act to pare away the surfaces, taking off chips, and not dust. A class of machinery, therefore, very different from the

saws results from this difference in the direction of the grain relatively to the cutters. The cutters will be fewer in number, but with longer face; the feed-motions will always be by power, and special devices for steadying the work and preventing splitting will be necessary. Where, beside the production of surface, the tool must bring to exact plane dimensions, a carriage or dimension-planer will be required. For ordinary board work, which is yielding, a surfacer is used.

Surfacers may be of two kinds: the bed may be stationary while the stock passes over it driven by feeding-rolls, or the bed may travel under the revolving cutter, carrying the stock with it. The larger tools are of the first class, with stationary bed; many small ones are now built with the traveling bed. There is also a difference due to the method of adjusting for thickness; the rolls may rise or the bed may fall. The surfacing-cutters are knives of a length suitable to the size of the machine, which are bolted to flat surfaces on a cylinder. This cylinder is made to revolve rapidly, while the stock passes against the revolving edges. These knives are of an appearance and shape shown by Fig. 418. The slots are for the bolts which fasten the knife to the cylinder. In that form there is

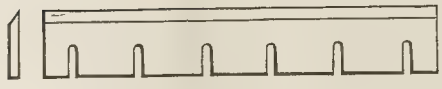


Fig. 418.

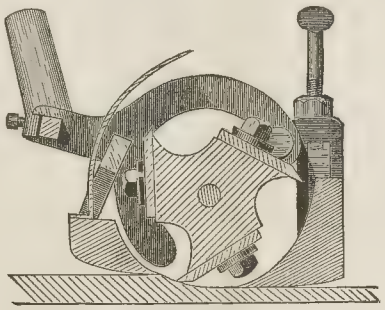


Fig. 419.

chance for adjustment, as the knives are ground narrower. The cylinders carry either three or four knives usually. The flats for the knives are shaped so as to act as a cap or chip-breaker. The cylinder is made of forged steel in the best practice, all in one piece. Very good results are obtained by the use of wrought-iron bodies, into which the spindles are forced or shrunk, and one builder casts the body around the spindle, using a so-called welding compound to effect the joint. The planing of T-slots in the faces of the cylinder for the heads of the knife-bolts is best practice. Many builders plane slots in two sides, and have the other two sides with tapped holes only. Some have no slots, but tap all holes. This obliges all knives to have equally-spaced slots, and twisted bolts or stripped threads are serious annoyances. This cylinder, with its knives, is driven at 3,000 to 4,000 revolutions per minute. Inasmuch as the cutters turn against the incoming stock, some form of pressure-bar is required to prevent the splitting of the surface in front of the cutter and to steady it after it leaves the cutter.

Fig. 419 illustrates an approved form of bar on each side of a three-knife cylinder. The stock is moving from left to right, while the cutting-cylinder turns in the direction of the hands of a watch. The front bar rises upon an arc of a circle around its pivot, behind the knife. This pivot is raised with the adjustment of the cylinder-boxes, and the bar always swings in an arc close to the cut. Some use a roll for a pressure-bar and have a separate pressure from the shaving-guard to serve as chip-breaker. The rear pressure-bar is either stationary or rises and falls beneath rubber compression-springs, which are adjustable. Some claim a yielding bar produces waves in the surface. Weighted levers are used for the front bar in most frequent practice. In the design of Fig. 432 the pressure-bar is pivoted on the outside of the cylinder-boxes, so that the lip of the bar is always one-fourth of an inch from the cutting-edge of the knife. A handle rests on the feed-rolls to prevent an extra-thick piece from catching on the corner of the pressure-bar. A few use rubber for the front bar as well as for the rear. In another design the bars rise and fall in grooves struck from the cylinder center, and so keep the bars close to the cut. The reason for seeking the closeness of these bars is that the knives may cut short pieces without striking the first end or spoiling the last end. The machine with this latter device has planed a 2-inch square of black walnut, and has reduced a slip of white pine from nine-sixteenths to one-sixteenth of an inch.

A few use a large friction-roller under the knife, to relieve the friction due to the downward pressure of the cut. This is opposed by some of the best builders, on the ground that the board bends over the roll if the latter projects enough to be of any use and the work will not be true. That this pressure downward is considerable may be proved by the fact that the tables are apt to wear hollow at that point. The design of Fig. 420, which is shown in detail by Fig. 421, and to which also Fig. 419 belongs, has a false plate below the cylinder, which may be renewed when worn. Often a strip of steel is let into the table at that point.

Fig. 421 shows one method of connecting the boxes at the two ends of the cylinder. The cylinder and knives in the first class of machines, with roll-feed and stationary table, must have a vertical adjustment for different thicknesses of work. The boxes, therefore, are fitted to move up and down and clamp in planed ways. This vertical adjustment is effected by screws, which are geared together by a shaft across the bed with bevel-gears

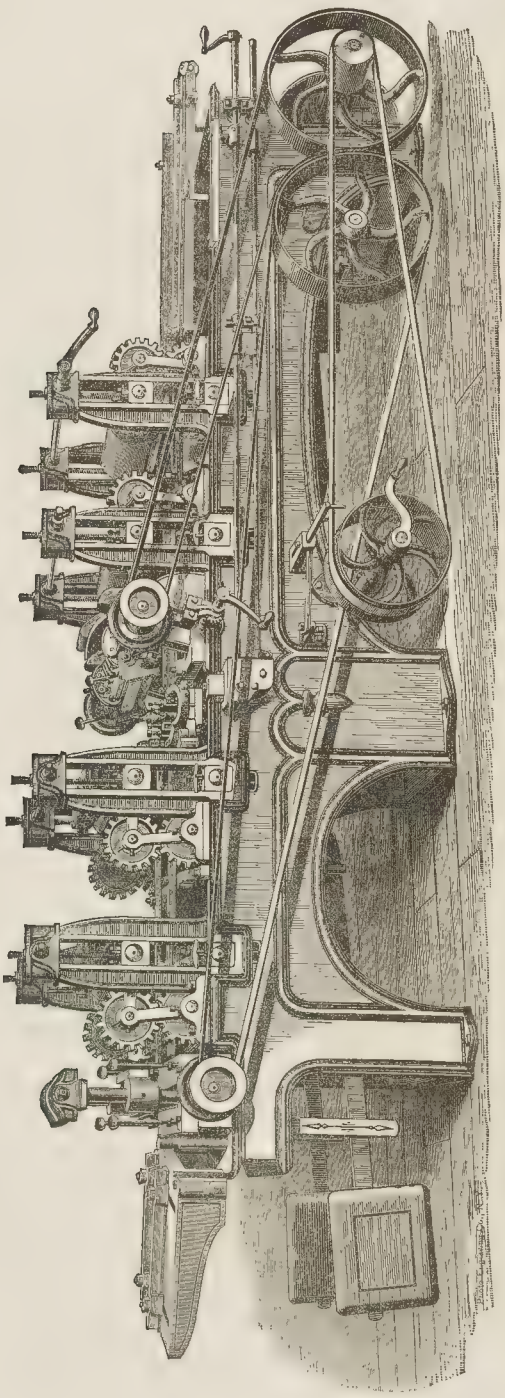


Fig. 420.

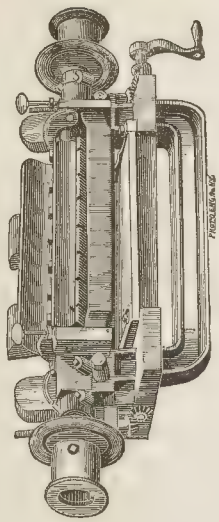


Fig. 421.

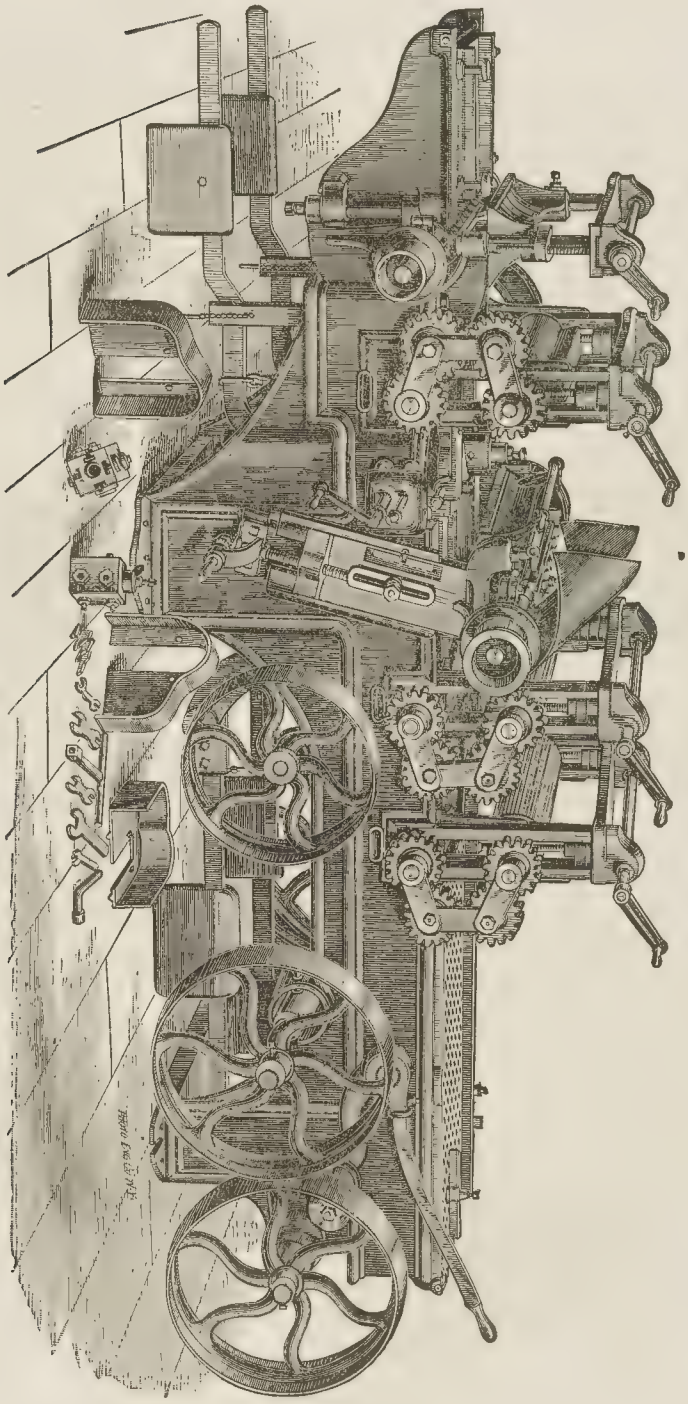


Fig. 422.

Many designers are content to depend upon the screws and the fit of the box-slides to keep the cylinder true and the boxes in line and free from bind; the best practice approves, however, the uniting of the boxes upon a yoke or cross-girt.

Fig. 421 shows the connection below the cylinder; Figs. 429 and 433 show the connection over it. Fig. 422 shows the type of arrangement in which the boxes are united through the screws only. The boxes are borne upon long oblique slides with wide bearing. The yoke below permits easy access to the cutters from above. Otherwise, the yoke must be high, as in Fig. 433, when it must be heavy in order to be stiff. A graduated scale indicates the thickness of the finished stock for each position of the cylinder. Babbitted boxes, with oil-cellars, are almost universal for these high-speeded spindles. In the best practice the babbitt-metal is bored out and scraped to a fit.

The larger types of tools which have been selected for illustration surface on the bottom as well as on the top. For this purpose a lower cylinder is used, driven so as to take a smoothing chip from the stock which passes over it. This lower cylinder in the majority of designs is put near the delivery end of the table. It is so placed that access to it shall be easy. Either the end of the table swings laterally out of the way (Fig. 420), or else the cylinder moves out straight sidewise upon ways (Fig. 434), or the whole roll and projecting table gear may swing. There is usually no adjustment necessary for this roll, and it always takes a standard cut. Its pressure-bars may be, therefore, of the simplest type, either fixed or with rubber springs. The lift of the cut is resisted by a short platen, adjustable by geared screws. In the designs of one builder (Fig. 434) the lower roll comes first in the series. There seems a certain logic in this arrangement, especially where the tool is a matcher as well as a planer. The

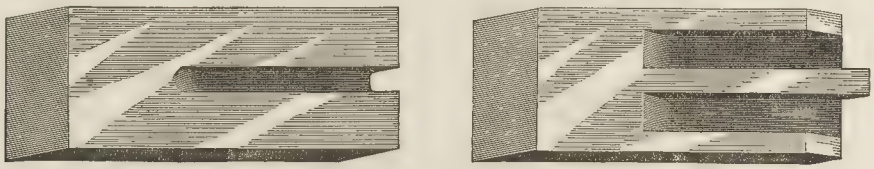


Fig. 423.

bottom of the stock is trued first, and from that faced surface as a basis the other cutters operate. Otherwise the first three cuts are made while the stock is guided by an unfinished and possibly untrue lower side. There is less objection to the older arrangement where the tool is a planer and surfacer only. The lower cylinder is most usually driven from a belt-wheel on the machine, which is turned by the friction of the belt to the upper cylinder (Fig. 420). The large wheel of the former pair acts as a kind of guide-pulley to the belt of the latter. The cylinders are driven from both ends in the best and largest types.

To secure largest output and income from a machine demands that it shall surface all four sides of rectangular lumber by once passing it through the machine. Therefore, beside the upper and lower cylinders (Fig. 422), there

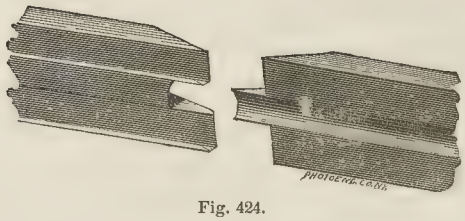


Fig. 424.

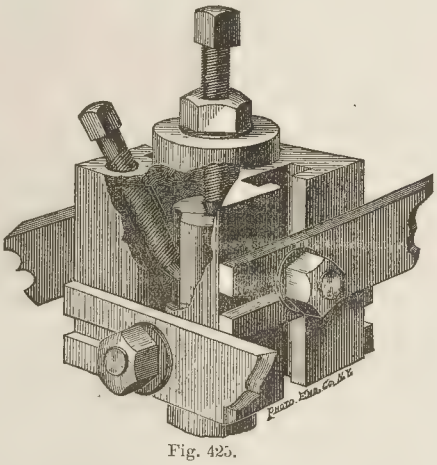


Fig. 425.

will be two vertical cutter-heads for operating on the vertical edges of the stock. These lie usually between the horizontal cylinders, and are driven by quarter-twist belts from a long drum or wide pulleys on the shaft at the extreme right. These belts are inside the bed, and some builders have special devices to keep them from overlapping. For board-machines there may be plain, narrow cutters, or there may be matching-cutters, to produce a tongue on

one side and a groove on the other. These matching-cutters may be milled from the solid (Fig. 423) or may be of the sectional type (Fig. 424). The general construction of an approved form of side head is shown by Fig. 425. It is here shown for molding-cutters, but any form of cutter may be used. The set-screw, which confines the head to the spindle, enters obliquely from the top, instead of radially from the side. The taper-point enters the spline and wedges the head fast without burring up the spindle.

Fig. 426 shows the more usual form, with radial screw. It is shown mounted upon a convenient device for insuring the proper adjustment of the cutters before the heads are put in place. When working upon thin boards, and especially upon brittle kiln-dried lumber or knotty and cross-grained stuff, the side heads are liable to split

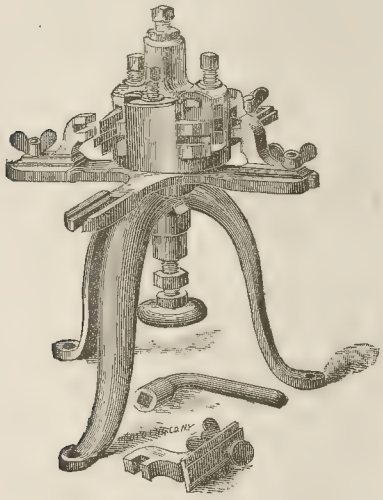


Fig. 426.

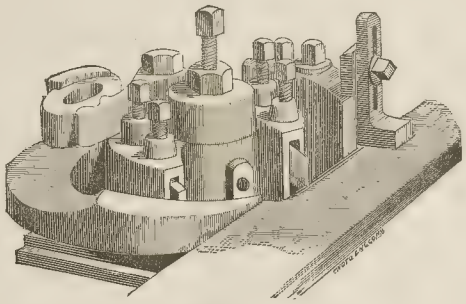


Fig. 427.

off slices or make a rough cut. To avoid this a side-pressure bar is used, consisting of a lever pressed by a spring in front of the cut, or in a patented design (Fig. 427) of a hinged chip-breaker, pressed against the side of the board exactly as the top pressure-bar of the same builders (Fig. 419). It is claimed that higher feeding-speed is possible with a device of this class. Both side heads act at once in planing- and matching-machines. It becomes

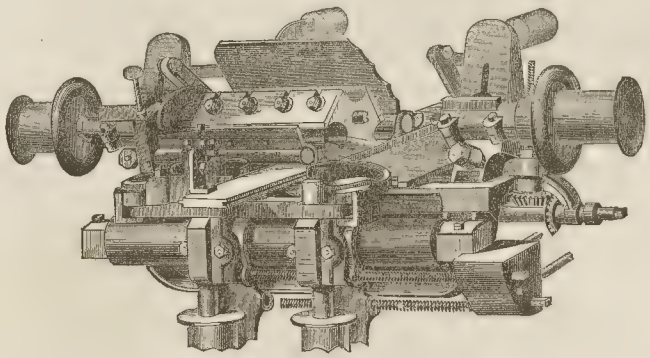


Fig. 428.

necessary to have the side heads adjustable laterally for standard widths of stock. This is effected usually by having the boxes for these side heads movable laterally. The boxes are upon slides, which are gibbed to transverse ways, and the slides may be set at any point by screws from the sides (Fig. 428). In some older designs the two heads were on one right and left screw, which moved both equally from the center. It is approved now to have each head controllable by a separate screw. The whole width of the planer-knives may be dulled before regrinding is necessary, and the bed does not wear so hollow in the middle. The lower boxes in the best practice have a special separate lateral adjustment to bring the spindles truly perpendicular or at a desired angle to the table, and there will be a slight vertical adjustment for exact setting of the cut. A steel tail-screw supports the foot of the spindle. When desirable to surface over the whole width of bed, the side heads in the design of Fig. 429 and many others may be lowered together out of the way by the rack and pinion device shown. The side heads themselves are made of gun-metal in the best practice.

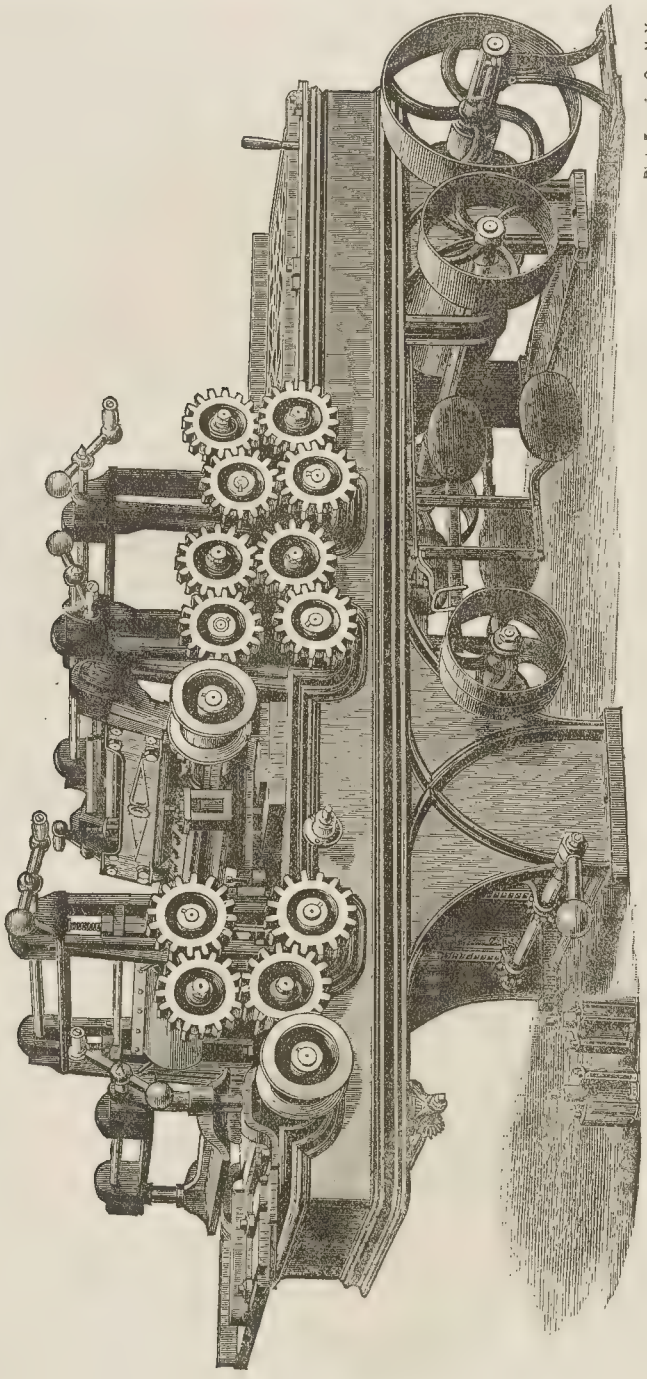


Fig. 429.

Fig. 430 shows the application of a small cutter-head at the extreme end of the machine, for beading or working up novelty siding. It will be driven from the main cylinder. This may be applied to any of the designs if called for.

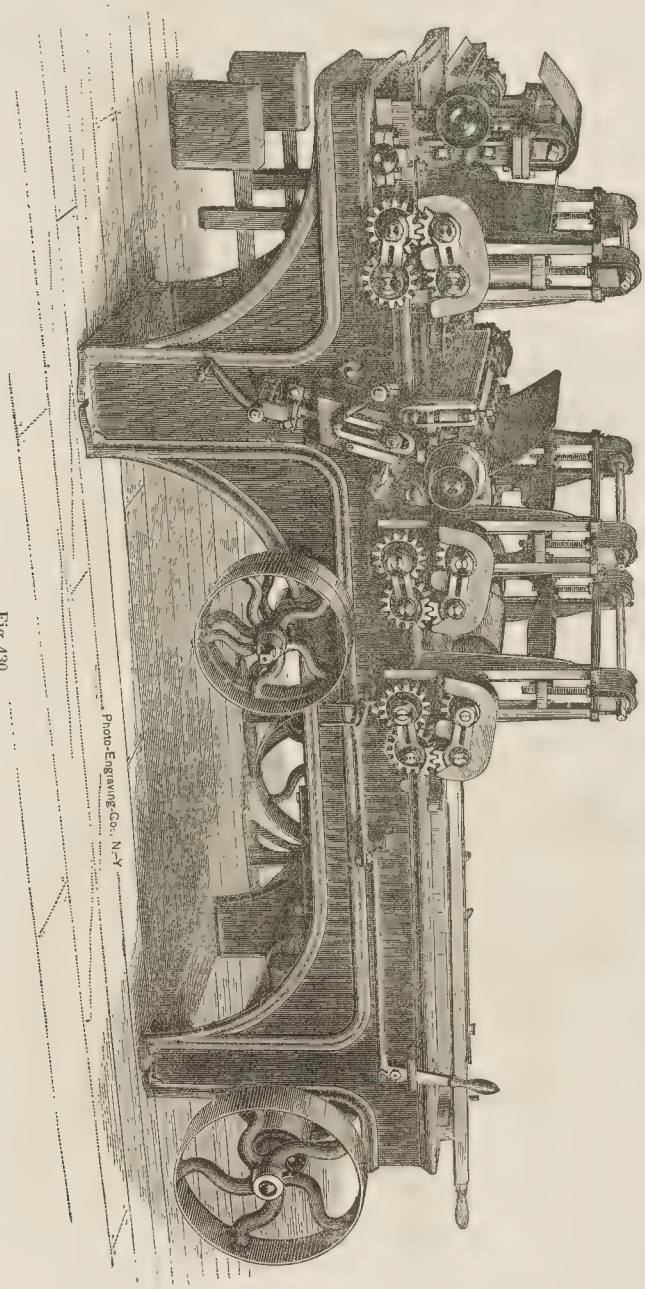


Fig. 430.

Since the action of the cutters is very forcible against the motion of the stock, it is necessary that the latter be fed in by power to the knives. In the tools of the class under discussion this feeding is done by driven rolls, which are weighted to grip the stock between them with sufficient pressure. The lower one is stationary, lying

just above the bed, while the upper one is adjustable for great variations of thickness by geared screws, and for slight incidental variations by the yielding of the weighted levers. The lower rolls (of which there may be two, four, or six) are geared together, the first one being driven by a belt from the cylinder usually, or else from the driving-shaft. The feed-belt is often made too long, so as to hang loose, and the feed is engaged by moving a lever which tightens the belt by guide-pulleys. There may be two belt speeds for feeding hard or soft lumber (Fig. 433), and they may have other special devices for reducing the speed or for engaging and disengaging. The cog-wheels which gear the lower rolls together are usually made large, and are on the right side of the machine. They are shielded in best practice. To permit the rise and fall of the top roll as thicknesses may vary is the object of the "expansion gearing", as it is called. In its original and simple form this consists in two idle wheels, which are upon floating pins linked together and to the upper and lower roll respectively (Fig. 422). The driving-motion from the lower geared roll passes through the train to the upper roll in whatever relative position the train may be, and thus a variation of 10 inches of capacity between the rolls is made attainable. The upper and lower roll of course turn in opposite directions. In its earlier forms these links for the gears bore on the axes of the rolls. Better practice fits them to the outside of the roll-boxes, and thus the wear on their fit is much reduced. They are also doubled in good practice to prevent the overhang of the intermediate studs. Most machines are geared at one end only. The machine of Fig. 420 carries the motion across by light shafts swung on the links (Fig. 431). These replace the studs of early designs. By this means a very strong and even feed is secured, and there is less danger of the cramping and wear of the gears. But a drawback to this feed-system by simple links is found in the supplementary motion imparted to the upper roll when it rises while revolving. Beside the driving speed it receives an additional rotation from the motion of the axes of the wheels around the centers to which they are linked. Whenever this occurs a variation in feed-speed occurs, and a wave or ripple is made in the work. To avoid this the design of Fig. 429 has the expansion in the upper pair of wheels only. The second wheel from the lower roll is stationary on a stud. The third wheel is upon a stud which has a horizontal motion in a slot, while the fourth wheel is linked to the third from the outside of the box. The first and the third and fourth are on different vertical planes, while the second has a very wide face.

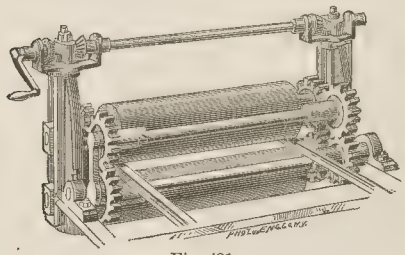


Fig. 431.

Fig. 430 shows what is called the Burleigh expansion-gear applied to the rolls, and Fig. 432 shows a similar device for compounding the motion of the third wheel. When the second wheel is lifted the curved slot gives a neutralizing motion to the train.

Fig. 433 illustrates a type of large planer and matcher in which the expansion-gear is partly inside the frame. The lower roll drives a gear upon an arbor, which passes through the framing, and an equal gear on the outside carries up the motion to the upper roll. The same design illustrates a usual type of guide for the stock that any tendency to "slew" may be prevented and to guide the material straight when the machine is used as a molder. There is also an illustration of a type of carriage for use upon grindstones to cause a straight edge on the knives.

In the types selected for illustration of present practice the bed is made of two sides, which are joined together by cross-girts. These sides may each have two or three legs. The cross-braces are bolted to the sides by bolts in reamed holes, and the true fit of the contact surfaces is secured by facing their bearing areas. The rude practice of bolting them together as they came from the sand is very generally condemned. The joints jarred loose, and the bed was not true. One builder, beside facing and bolting the braces, uses steel dowels for further stiffness and security. The most advanced practice tends toward consolidation of parts and casting in one piece as much as possible. Fig. 434 illustrates a departure in this direction. The four cylinders are attached to one central trough-casting, which bolts in place in a hollow of the bed. The lower surfacer acts first. By the system of expansion-gears in two planes the advantages are gained of the use of gears larger than the rolls. The weighting of the rolls is effected by a very neat mechanical device, by which no adjustment of the linkage and levers is required as the rolls are lifted to take in thicker stock. The adjustment also by hand does not need to overcome the feeding-weights, but the latter act immediately when any one roll rises separately. The rolls are lifted by worm and wheel combinations driven by hand-wheel or power. The worms are splined to their shaft, and their motion in one direction is resisted by a collar, while the bent levers connected to the weights press against their other ends. These bent levers hold each other in equilibrium when no pressure is on the rolls, or when they are lifted or lowered together. Should one roll be forced to rise by thicker lumber below it, its rise tends to turn its worm-wheel and to move the worm along like a rack. This rack-like motion is resisted by the weight and bent lever of that roll. The upper and lower cylinders are separately driven by a shaft at each end of the bed. The lower head can slide out upon ways, and the matcher heads have ample adjustment in all directions.

The chief feature of Fig. 435 consists in the use of cutter-heads with nine knives, instead of the usual three or four. The knives are of thin steel, with a cap. This divides the duty of cutting, and enables a high feeding-speed to be used. The standard speed for this machine is 150 feet per minute. The older practice approved from 20 to 50 feet, which is still all that some machines admit of. The feeding-rolls on this machine are large, of 9 inches in

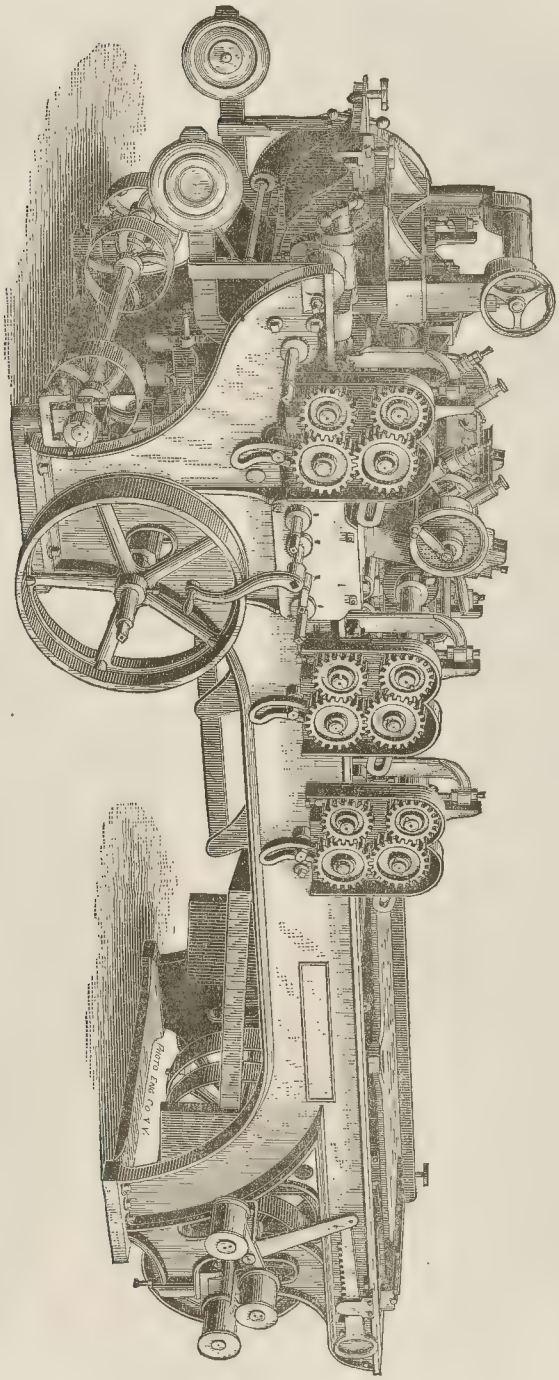


Fig. 432.

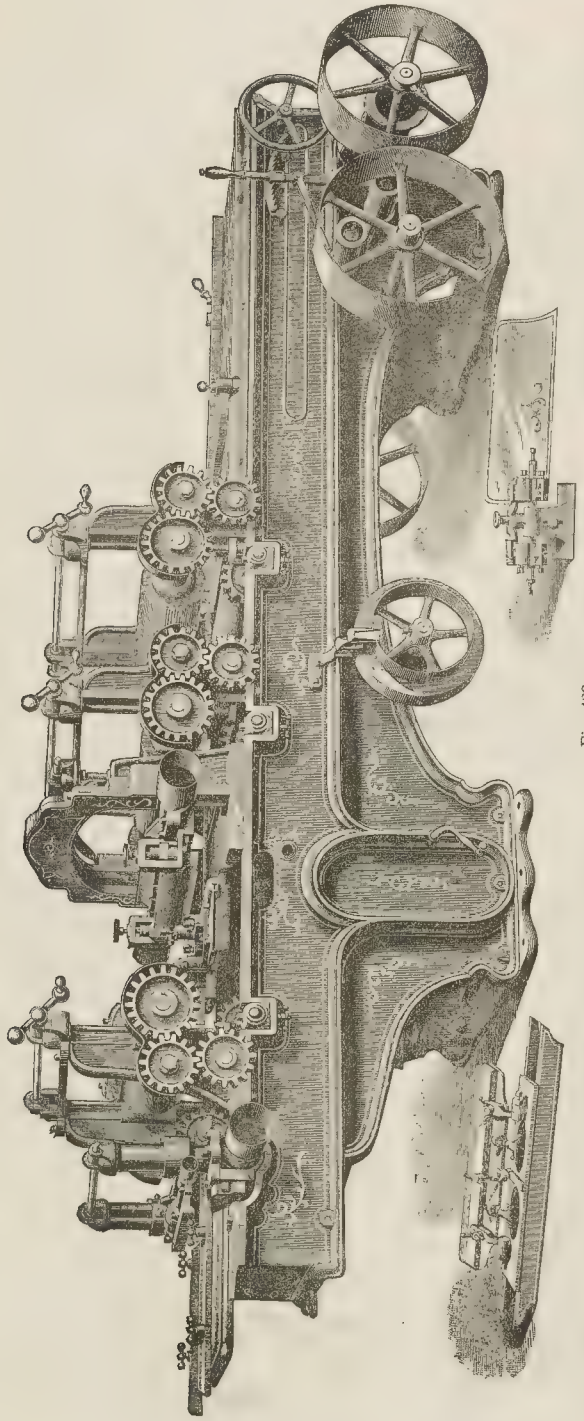


Fig. 433.

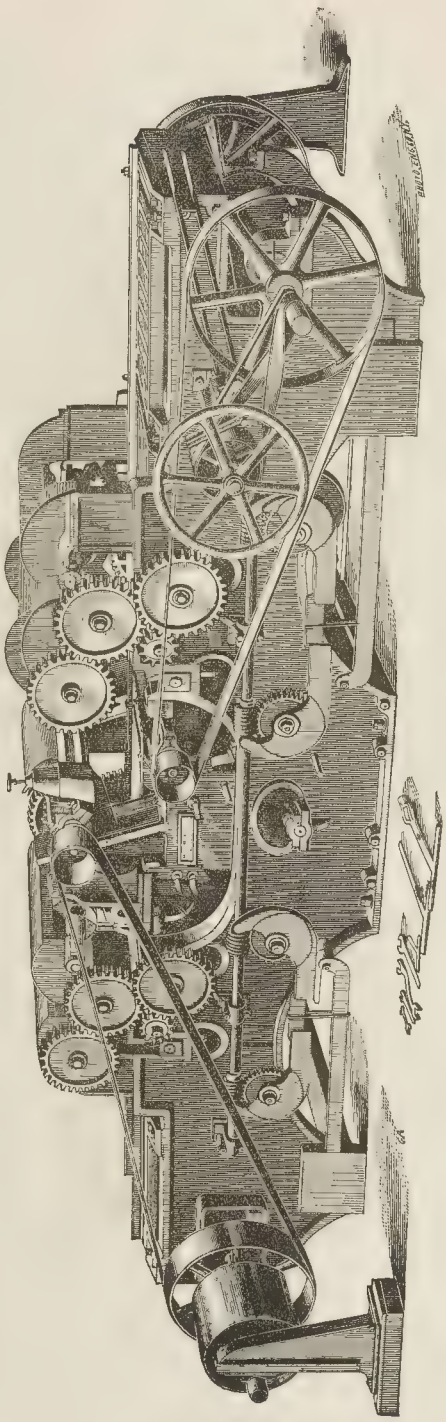


Fig. 434.

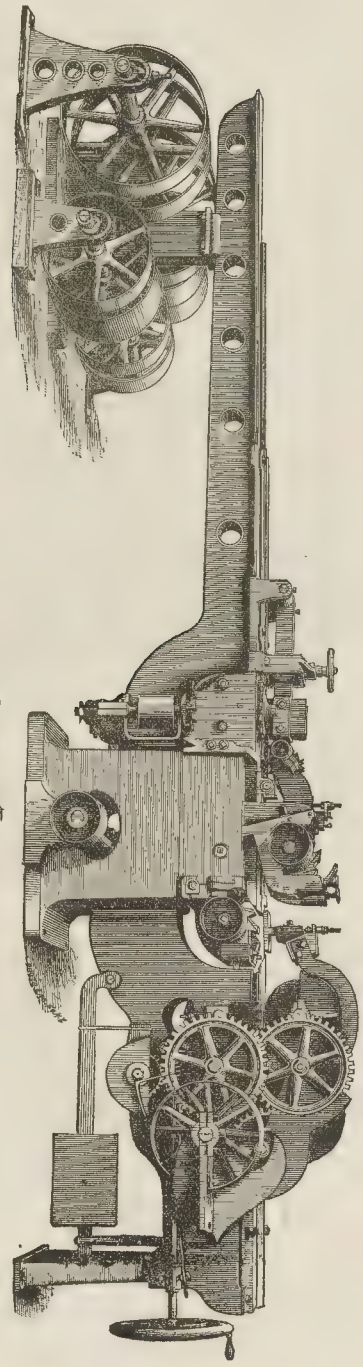


Fig. 435.

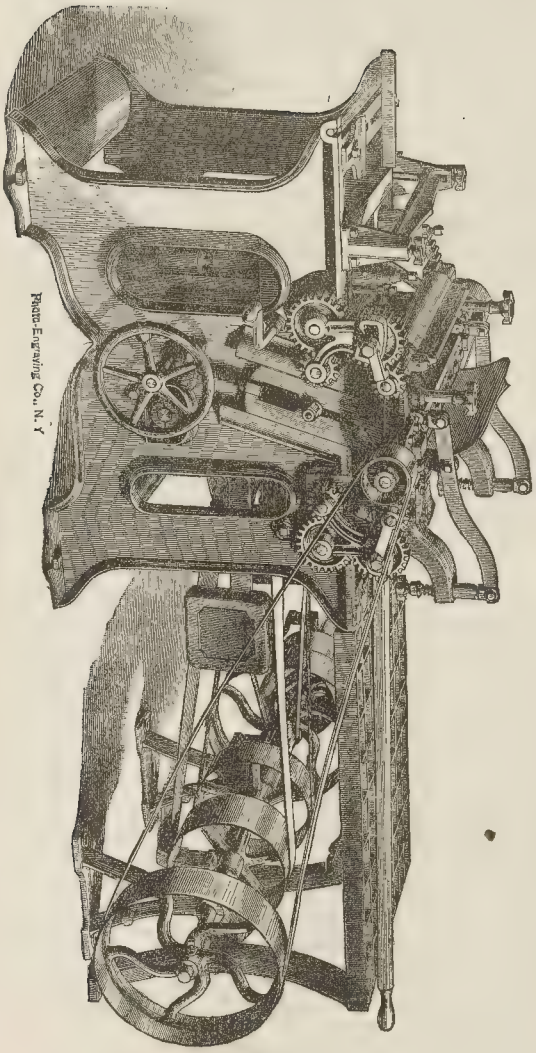


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Fig. 436.

diameter, and the upper one is fluted, while the lower is plain. Fluted rolls are usually of small diameter, of 2 or 2½ inches, in other designs, while a great many use all smooth rolls. One designer, driving the rolls from both ends, divides the rolls in the middle. This permits boards to be fed side by side, even though they may vary in thickness, and thus nearly doubles the output of a surfacing-machine. With solid rolls the thinner board will cease to be fed, because the thicker board has taken off the pressure from it. The rolls driven from one end, from difference in the leverages of the weights, will feed a board obliquely sometimes, which gives trouble at the matcher-heads.

The suppression of many parts of the larger machines selected as types is very usual. This gives rise to a series of simpler and cheaper machines, adapted for special classes of work and special financial conditions. Figs. 436 and 437 show two types of such machines. Fig. 436 is the older form, and shows an especial arrangement of expansion-links. In Fig. 437 the principle of one casting is illustrated. The feed-rolls are driven by worm-gear.

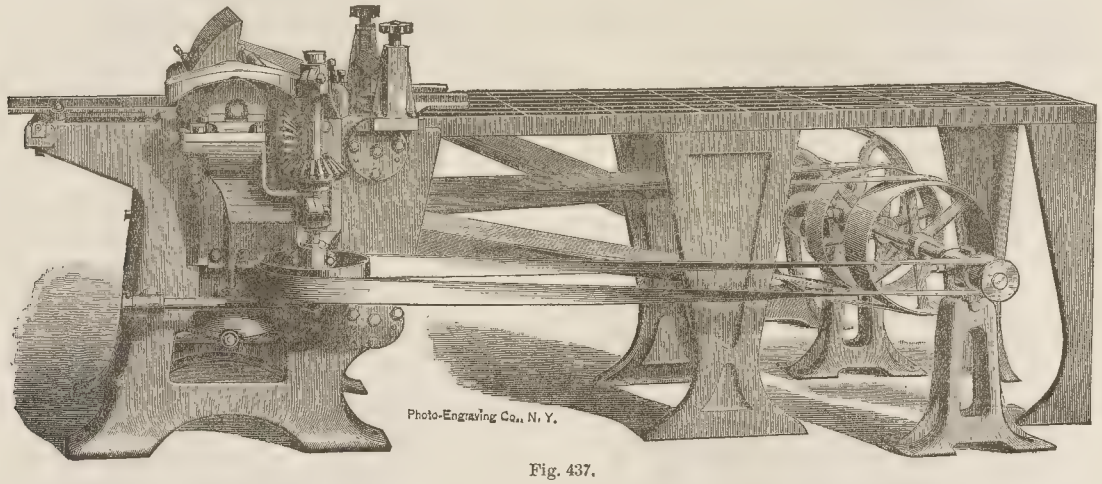


Fig. 437.

The knives in both are set with a retreat at one end of 1 inch in 24 inches, so as to give a dragging or shearing cut. This increases the smoothness of the surface in some woods. They require no further detailed allusion. The machines discussed are the successors of those made under the original Woodworth patents, which ran from 1828 to 1856. These patents were for the combination of rotary cutters and holding-down rolls which are required in all designs. The first machines were built with wood frames. Iron frames were introduced about 1850. The decision with regard to the Woodbury pressure-bar claims as further released this type of machinery. The improvements in the later designs over the earlier have been in the direction of greater strength and stiffness of bed and frame, more ample bearing and wearing surfaces being provided, and steel is more largely applied. The capacities of the machine have been enlarged. The feed-rolls will expand for lumber from one-fourth of an inch to 10 inches. Timber, 8 by 8 inches, can be faced on all four sides in new machines for such work as that for which the elevated railways are calling in the cities. The output of the machine has been enormously increased. Records are accessible of 55,000 feet of 1¼-inch lumber planed on two sides in eight and a half hours. The lumber was from 8 to 11 inches wide. Ten thousand feet of lumber of similar width and 1 inch thick has been planed on one side in one and a half hours. It is claimed for the machine of Fig. 435 that it will surface 40,000 feet on four sides in ten hours, if not more, on a trial. These are great advances on the performance of earlier days, and may be taken as indicative of the rapid progress which has made possible such an increase in productiveness.

§ 43.

ROLL-FEED SURFACERS.

To meet a want for a machine which should be rapidly adjustable in miscellaneous shops the roll-feed planers, with lowering bed, have been introduced. The bearings of the upper cutters are fixed, and the rolls have only rubber adjustment, if any at all. The variation for thickness is obtained by lifting and lowering the whole bed or table by a crank or hand-wheel. The separate adjustment of the series of rolls is entirely avoided, the machine becomes much shorter and more compact, and a stiffness and solidity is obtained for the upper cutters which has commended the system very widely.

Fig. 438 illustrates a double surfacer and matcher of this kind. The whole bed is guided by long ways in the center, and is raised and lowered by screws geared from the hand-wheel. The lower rolls drive the upper through expansion-gear, and a tightener takes up slack from the under cutter. The matcher-heads adjust themselves with the table.

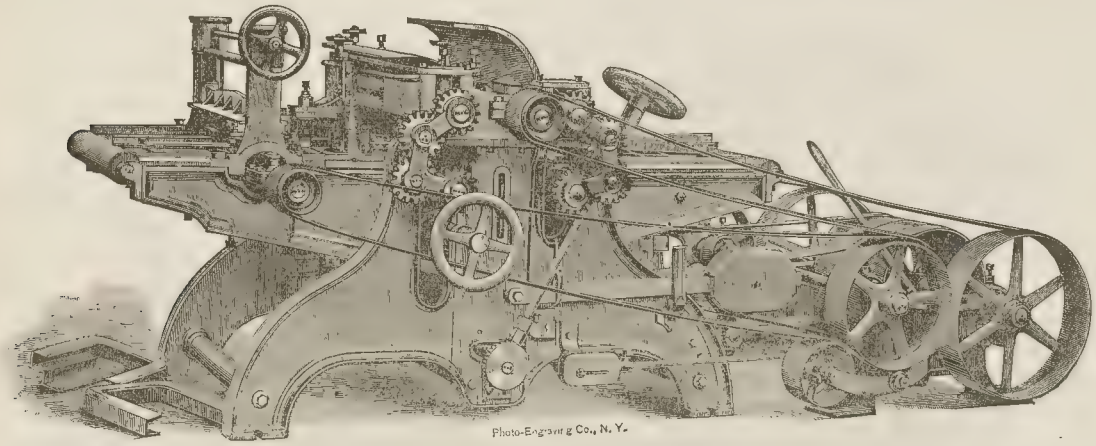


Fig. 438.

Fig. 439 illustrates a machine with both cutter-cylinders belted from one belt with tightener. The bed and all the feed-works give an adjustment for thicknesses between one-sixteenth of an inch and 3 inches. There are six rolls geared together expansively, the feeding-out roll carrying the stuff completely through. It swings out of the way to permit access to lower head. There are three changes on the cone-pulley of the feed-shaft.

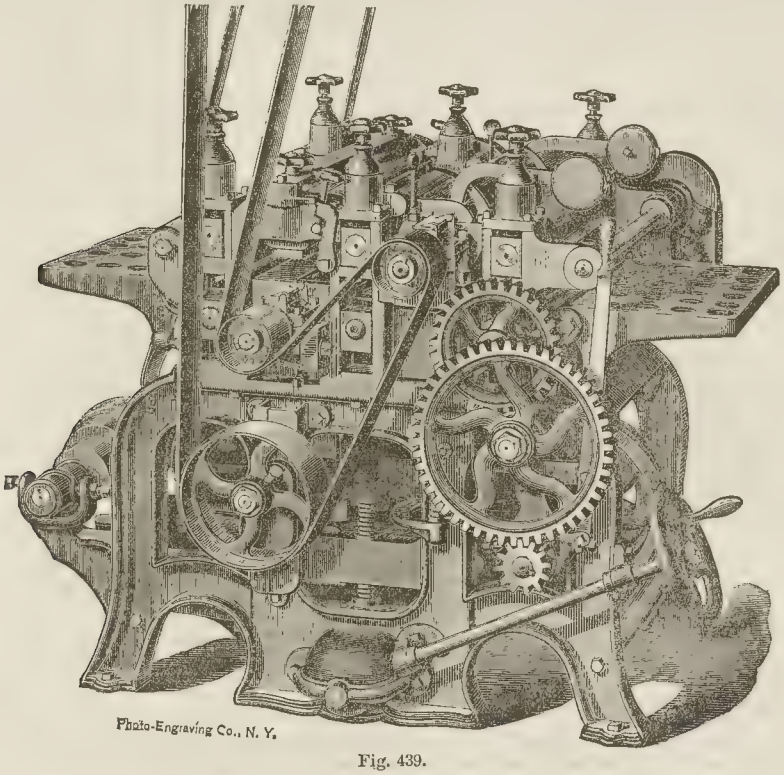


Fig. 439.

Fig. 440 shows a type of machine for upper surfacing and matching. After the long table has been set, the farther end may be clamped from swaying. It is raised with the central part by having its screw geared to the others by bevel-gears. There are four feed-rolls, and the counter-shaft is held on the lower extension of the machine. The feed-gear is engaged by tightening the loose belt.

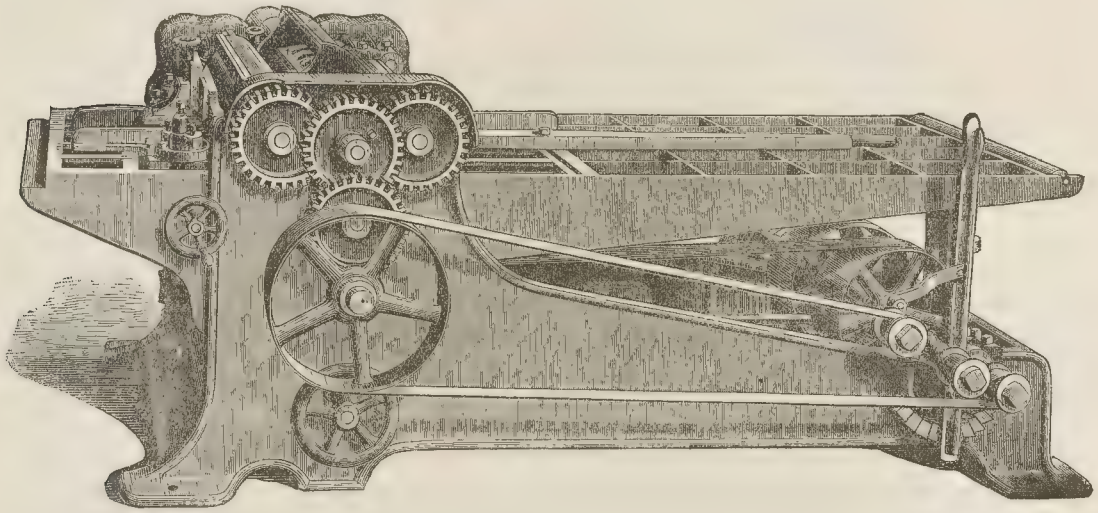


Fig. 440.

Fig. 441 shows a machine of excellent construction. The bed rises and falls by inclined planes, worked by a screw from the hand-wheel. One revolution of the wheel lifts the table one-eighth of an inch. The machine has capacity from one-sixteenth of an inch to $6\frac{1}{2}$ inches. The feed-rolls are driven by heavy gearing, which may be arrested instantly, and which permit two changes of speed. So powerful is the feed that half an inch may be taken off at one cut. The pressure-bars move in grooves concentric with the cutter-head, so that pieces of 3 inches in length may be planed without clipping the ends. The journal-boxes are self-oiling by a strip of felt put in a groove in the babbitt. The journals are long ($7\frac{3}{4}$ inches), and are belted at each end. Such machines will take in lumber up to 48 inches wide.

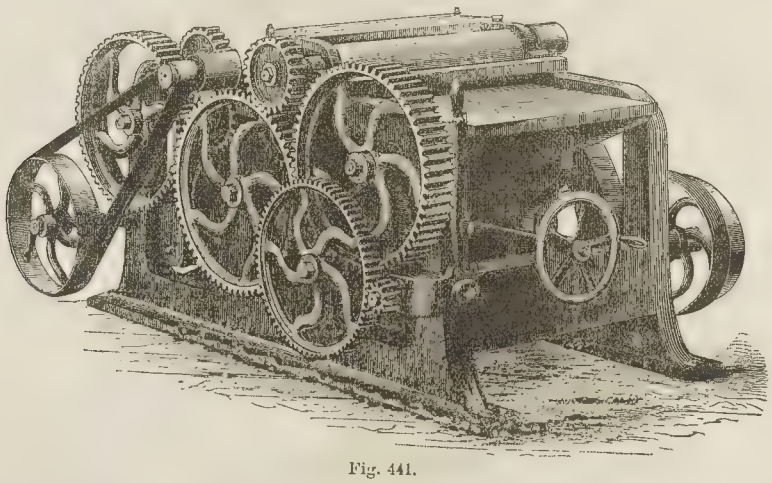


Fig. 441.

Figs. 442 and 443 show a very prevalent type of single surfacer, which is often called a "pony" planer. One shows rubber springs for both upper rolls, and the other has weights for the front one. The feed is controlled by tightening the belt. The adjustment for thickness is made by geared screws.

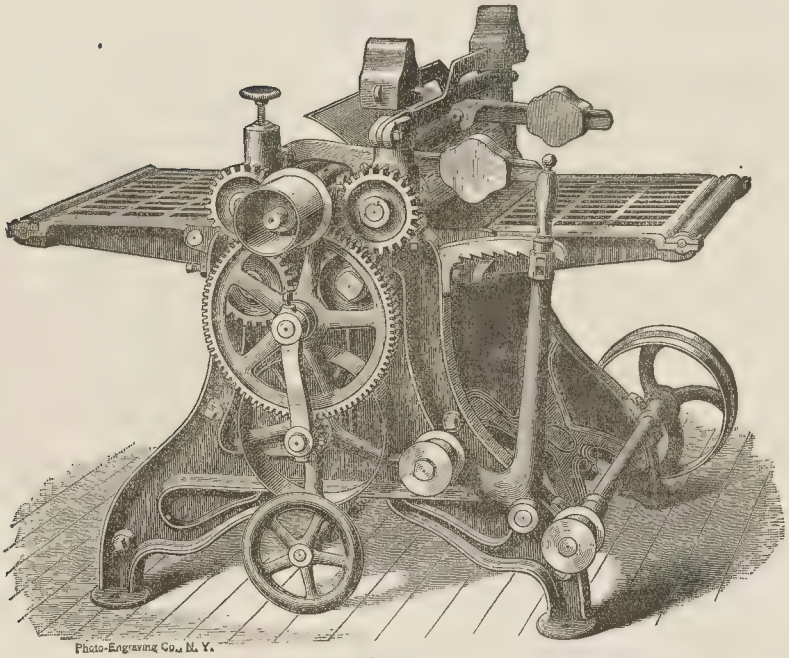


Fig. 442.

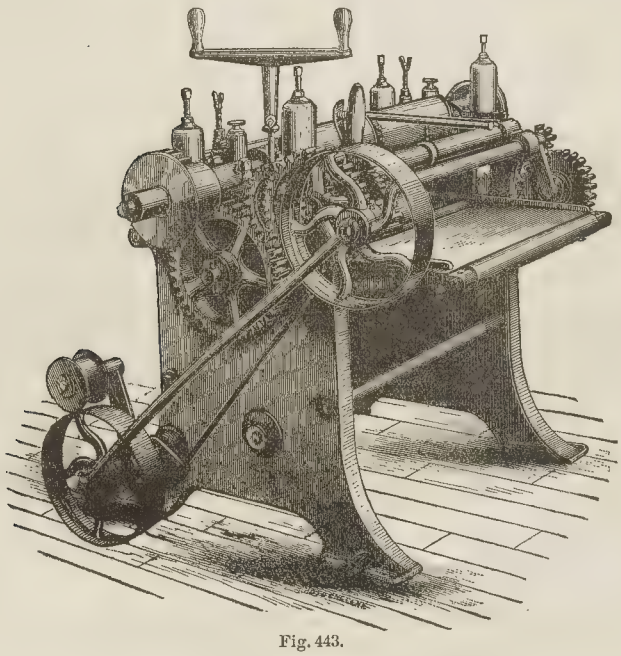


Fig. 443.

Fig. 444 illustrates a very compact pony planer, or panel-planer for finer and more exact work of short length. The bed adjusts for lumber up to 4 inches thickness by the hand-wheel. The rolls are driven by a neat application of the brush-wheel friction. The position of the driver is controlled by a lever, with a latch locking into a sector.

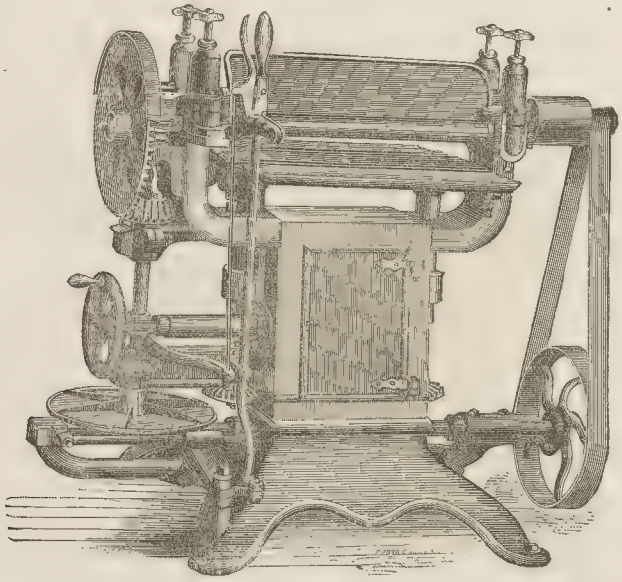


Fig. 444.

An ingenious release of the friction when the feed is to be shifted or reversed adds further to the excellence of the device. The opening of the latch lifts the face-wheel, and the weight of the latter acts as a latch-spring. A variation of feed between 20 and 40 feet is thus possible. For certain purposes, it is desirable that the cutter should act

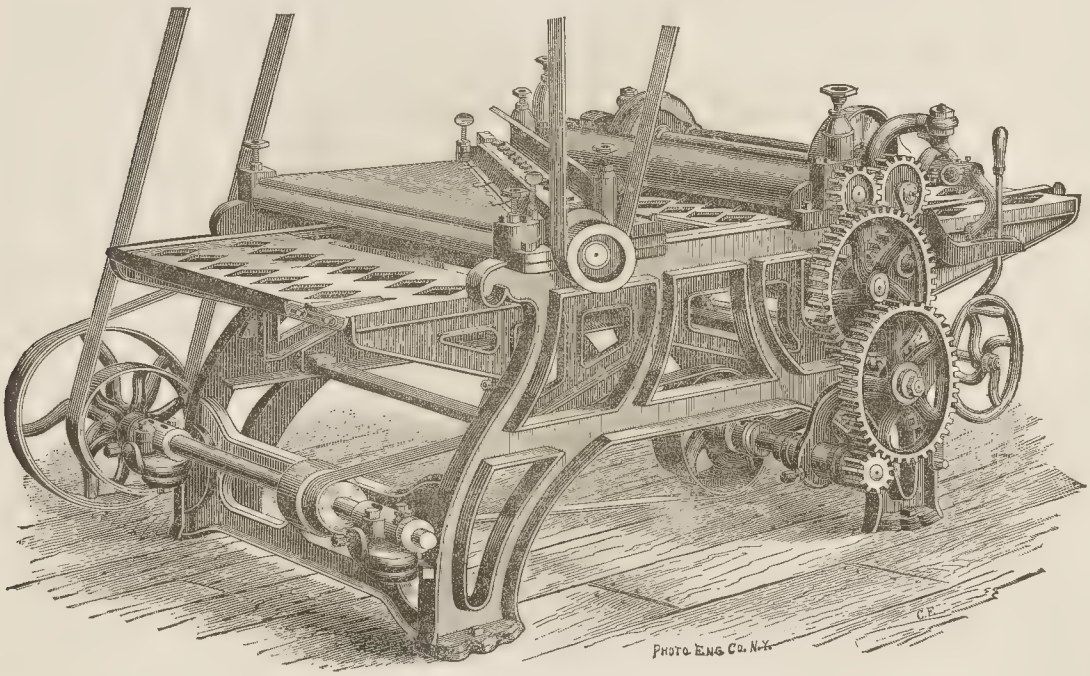


Fig. 445.

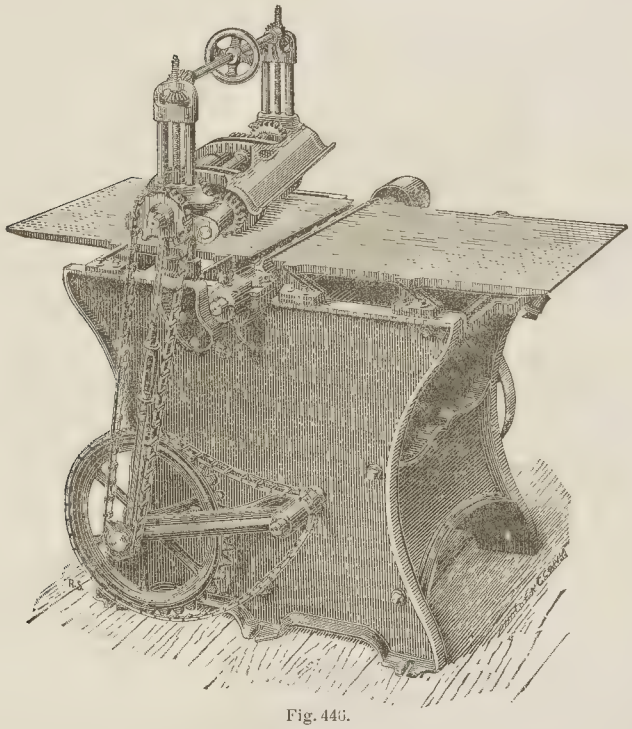
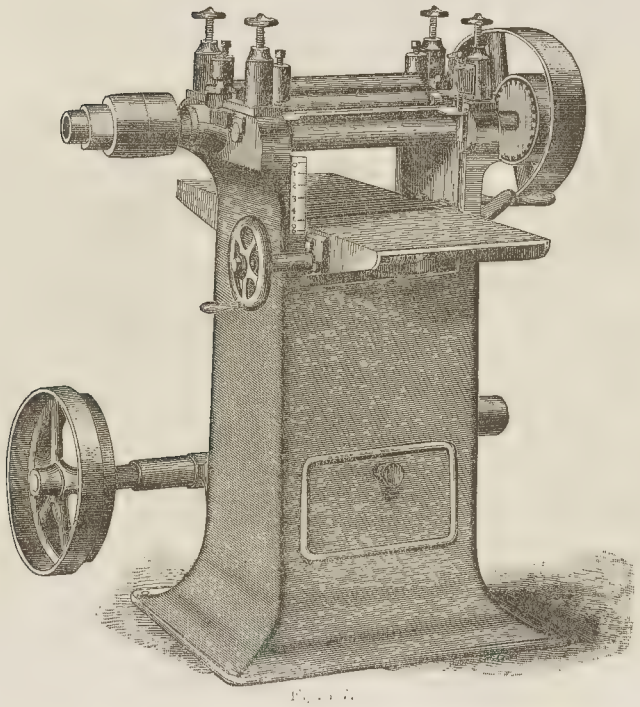


Fig. 446.



diagonally upon the stock presented to it. This is especially desirable for work made up of lumber with the grains running both ways, as in doors, shutters, and paneled work. Fig. 445 illustrates such a machine, with a capacity for 500 doors per day, working one door of 7 feet in length on both sides per minute. Tenons, wedges, etc., are cut off by adjustable saws at the work end, and the table adjusts for thickness by inclined planes. To counteract the variation in thickness of rails and muntins the pressure-bars have independent adjustments, that they may bear equally with requisite pressure on all parts of the surface. There are two changes of feed, disengaged at will.

Fig. 446 shows a diagonal planer, with feed by gearing-chain, using rubber bands on the rolls. It may also be used as a straight buzz planer. The great simplicity of Fig. 447 results from the arrangement for moving the table. The table is borne by a large round pillar, which fits inside the standard. A screw of gentle pitch is cut on the pillar, and a nut which fits it is revolved by a worm on the hand-wheel shaft. The screw on the pillar lifts and lowers, and the tangent gearing acts as a clamp. Pony planers or surfacers of this class are very useful and popular for small, short work, and for sized pieces. Long work would overhang too far to permit accuracy.

§ 44.

ENDLESS-BED OR TRAVELING-BED PLANERS—FARRAR OR LAG-BED PLANERS.

By the above names is known a large class of machines adapted for heavy and rapid surfacing. They appear in two general forms.

Fig. 448 shows the type in which the cutter-head and bars rise and fall, while the bed has no vertical adjustment.

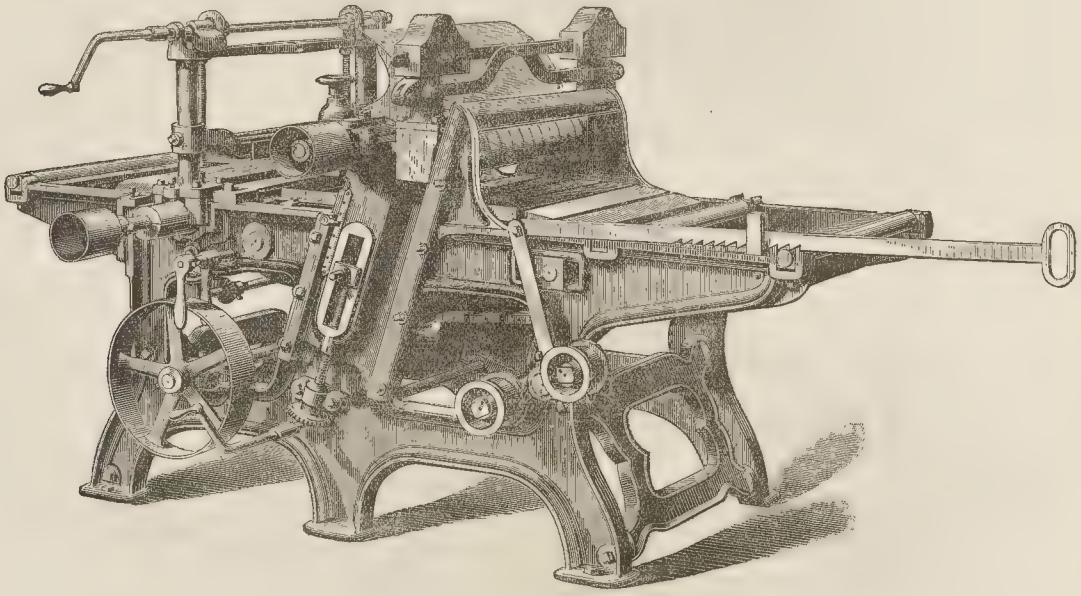


Fig. 448.

Fig. 449 illustrates the type with fixed head and adjustable bed. The latter type is the prevalent one, on account of the rigidity and stiffness which the fixed boxes give to the upper cylinder. The other system offers advantages when double surfacing is to be done. The stock is fed to the cutters by the motion of the bed on which it rests. This bed is made of slats or lags, linked together into an endless belt sidewise and driven by sprocket or polygonal wheels within the bight. These lags are supported upon longitudinal ways beneath the cutters. There are either two, three, or four of these ways. Against the three-way system the objection is urged of excessive wear on the middle one. There are two at the ends of the lags and one midway between them. The bulk of the pressure on the lumber is borne by this third way, since the stuff is instinctively presented centrally. On wide lumber the flexure of the thin lags will cause the surface to taper to one side after the machine has been in service for some time, or produce uneven thickness when the machine is changed from narrow to wide stock. To prevent this objection the two-way system is preferred by some excellent builders.

Fig. 449 shows a detail of the lags. They are cast with a deep web, to prevent flexure between the ways, and the latter are brought nearer together by linking the lags outside of them. Against the two-way system is the objection that it is possible for the lags to be lifted against the cutters by a pressure at their ends. This cannot happen, however, when the two ways are at the extreme ends.

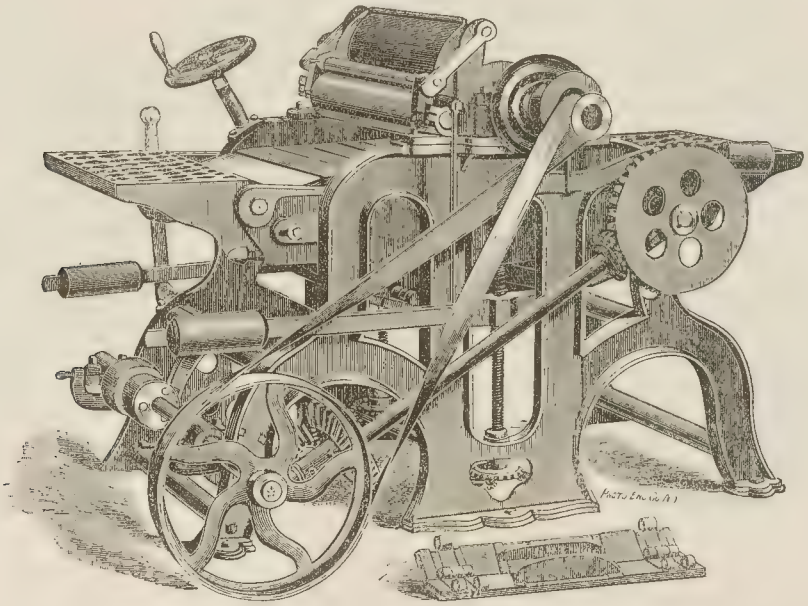


Fig. 449.

Fig. 450 illustrates a machine with four ways to counteract this latter danger and distribute the wear. The ways are provided with oil-cellars, which lubricate the lags as they pass over saturated fibrous material. The lower

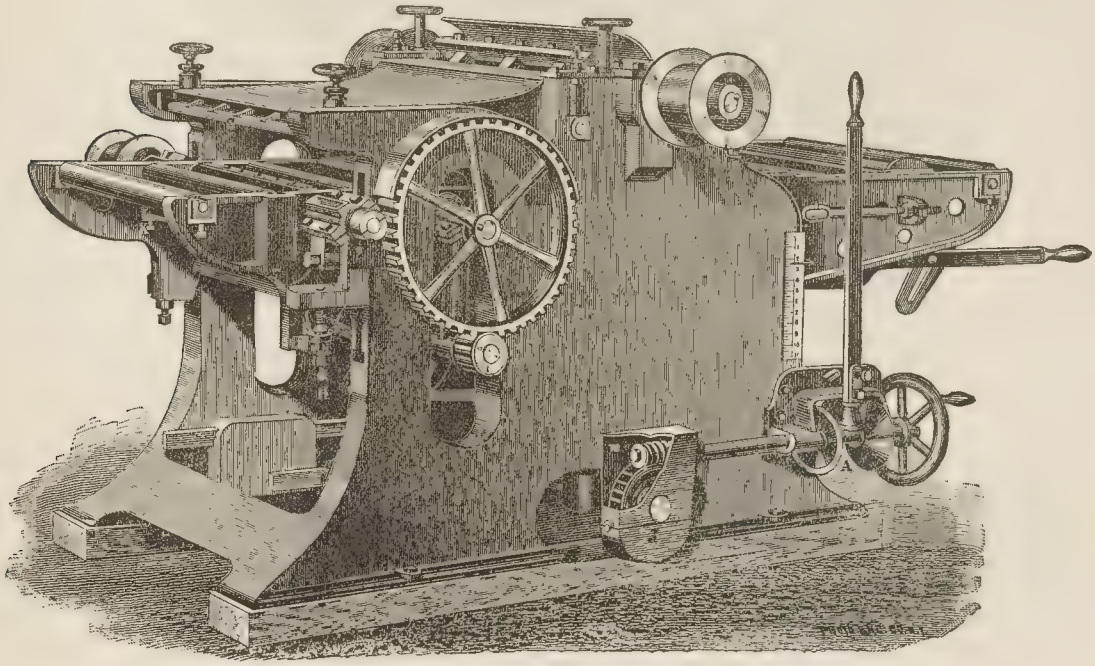


Fig. 450.

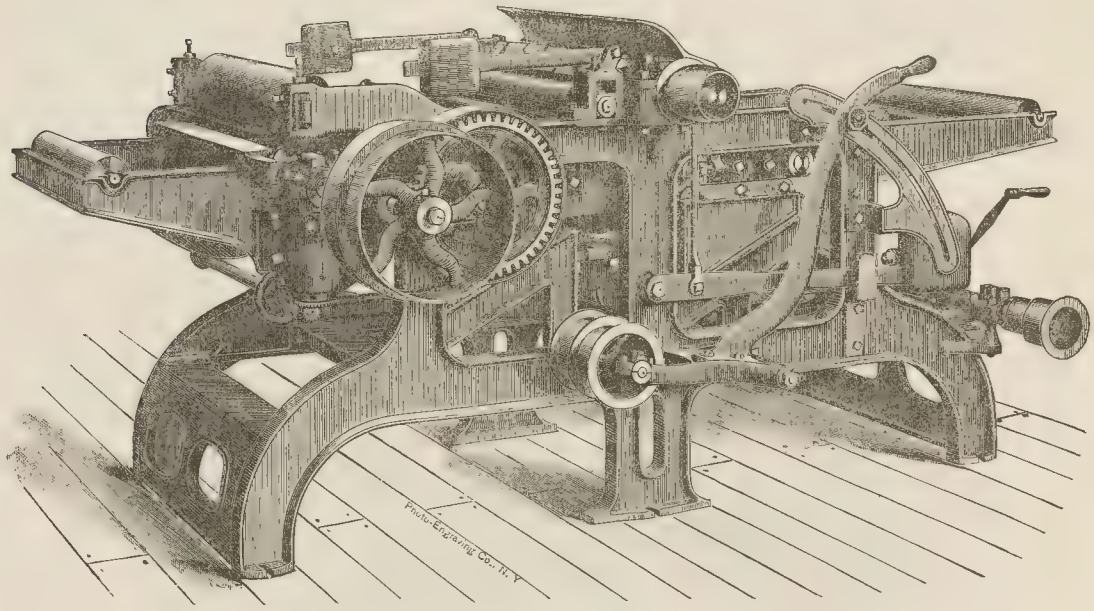


Fig. 451.

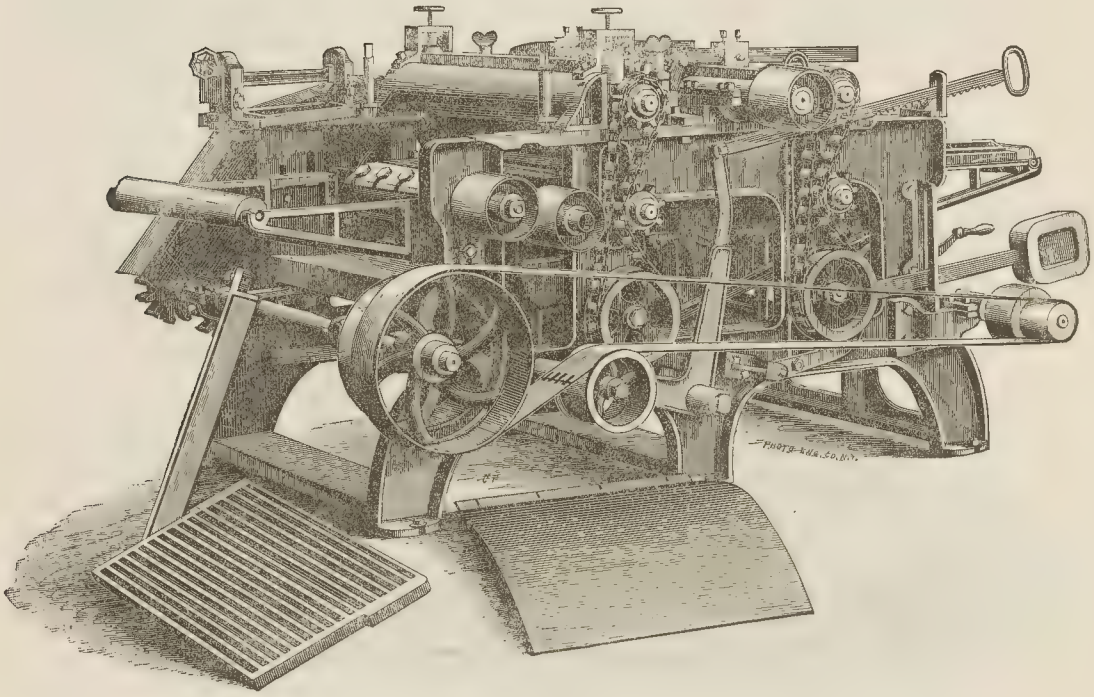


Fig. 452.

bight hangs slack and the sag can be controlled by a lateral adjustment of the bearings of the idle drum. The lags are linked together by flat links in commoner practice like a gearing-chain. The alternate single links are on the lags.

Fig. 449 in the detail shows the lags hinged together by ½-inch wrought-iron pintles, instead of riveted links. Special profiles have to be given to the lag-corners to prevent them from kicking up or chipping the lumber as they

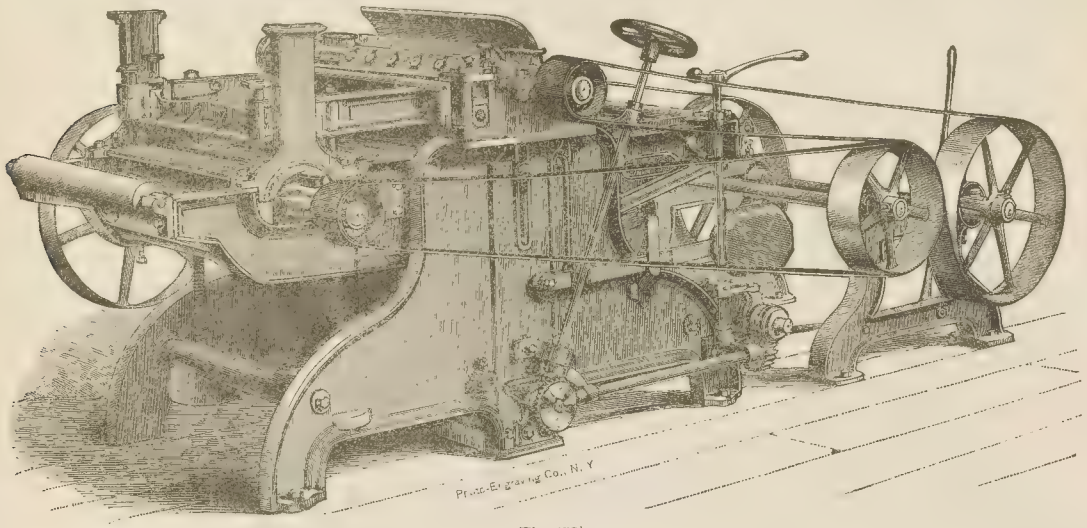


Fig. 453.

pass from the circular drum to the tangent ways. The driving-drum is always at the back of the machine. Fig. 449 shows it driven by bevel-wheels from a friction-shaft with two speeds. Fig. 451 shows the more usual system by belt-tightener, clamped to a sector. The upper pressure is found to increase the resistance to the feed if left plain. In best practice it becomes a roll, and the chip-breaker is separate. The latter comes close enough to the cut to be effective, but does not press so heavily upon the stock. These pressure-rolls are not usually driven, but are turned by friction of the stock.

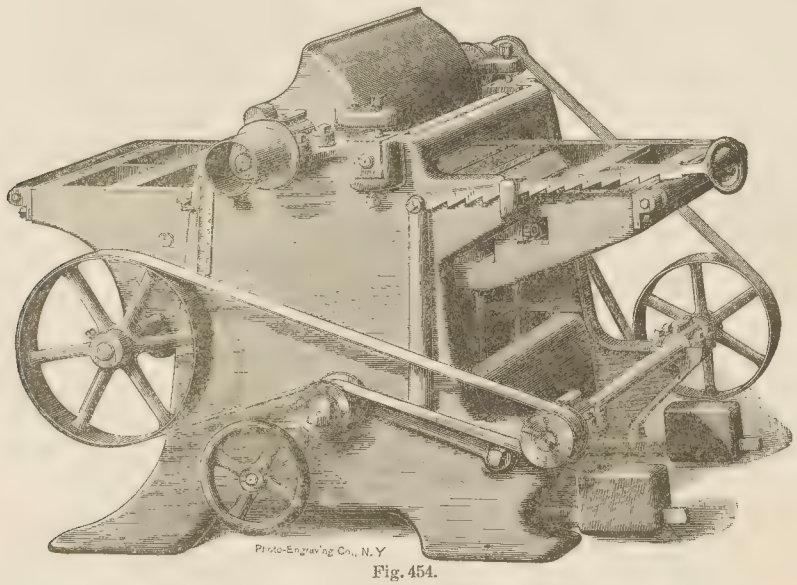


Fig. 454.

Fig. 452 shows the upper rolls driven by slack-gearing chain. The same builder uses this same device for his expansion gear on fixed-bed Woodworth planers instead of the usual links. The cut illustrates a double surfacer,

and shows the convenient method for freeing the lower head for inspection and sharpening. The grating of the part beyond the cutter-cylinder lifts away and the pressure-table swings out of the way. An objection to the double surfacers with adjusting bed is the difficulty of unsteadiness in the under head. This must rise and fall with the table, and the loose fit of the latter to permit motion magnifies the vibrations. In the design of Fig. 450 the boxes of the lower head may be clamped to the sides of the frame, making the lower head as firm as the upper. There are adjusting-screws to bring the two cylinders parallel, and hand-screws adjust the platen over the lower. The table is raised or lowered by screws geared together or else by inclines. It is guided and kept horizontal by

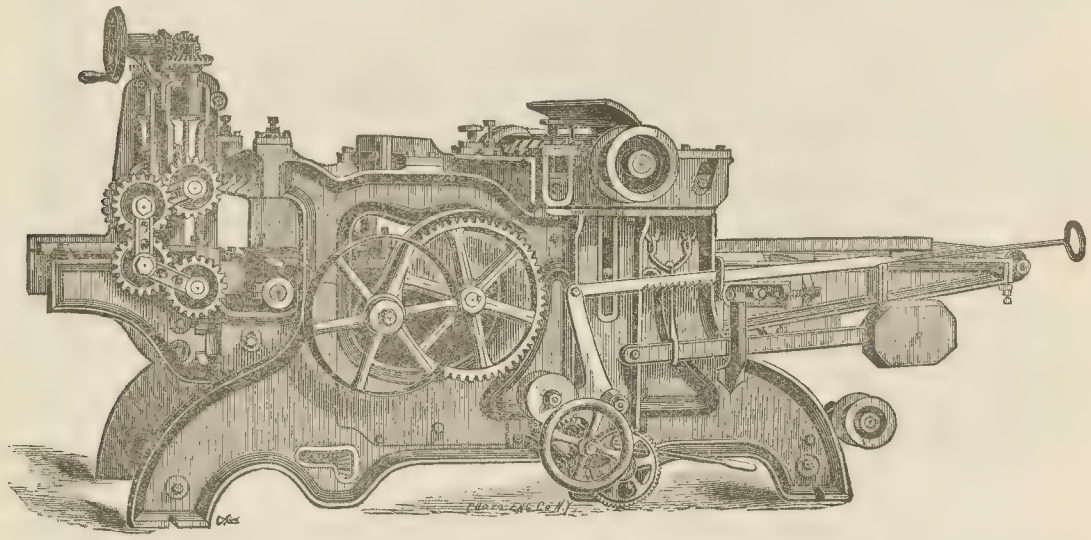


Fig. 455.

dovetail slides. Fig. 453 shows the screws geared from the power-shaft by short right-and-left worms. These can be engaged at will with the worm-wheel by the vertical shaft. Fig. 450 has the worm-shaft driven by friction from the central bevel-cone. There is also a hand-wheel adjustment in all cases. The types illustrated show the diversities of practice with respect to the resistance of the pressure-bars or rolls. Fig. 448 has the weighted levers cross each other, with a special integrating device at the center. Fig. 451 has the standard weighted levers, and some of the others show the adjustable rubber spring.

Fig. 454 shows the use of the shaving-guard as supplemental to the roll. An extension of the bonnet comes down close to the cutter-head and acts as a chip-breaker. The front roll lifts the bar and prevents the stock from catching on its corner. The other features of the designs will be visible from the cuts.

The endless-bed planers are not very extensively built as matchers also.

Figs. 455 and 456 illustrate very large machines of this type for dressing car- or bridge-sills, and similar 10-inch lumber. The system of Fig. 456 is not without its advantages in these heavy machines, since the weight of table and attachments does not have to be overcome. Extra feeding-out rolls are made necessary, in order to free the matcher-heads, which have to be beyond the end of the traveling bed. The cheaper and smaller type of Fig. 457 and the surfacers of a little larger size are by far in the majority. The endless bed planer, as a type, is especially adapted for fast work, which may be permitted to be rough. It can do very smooth work when properly built and slowly handled. It has done splendid service for lumber which was wet or icy, upon which the Woodworth rolls might slip or fail to catch. The weight of the work favors the feed, instead of resisting it. It has a speed of feed of about 60 feet per minute, and in its "pony" form is very popular, even to the displacement of the other forms in certain classes of work.

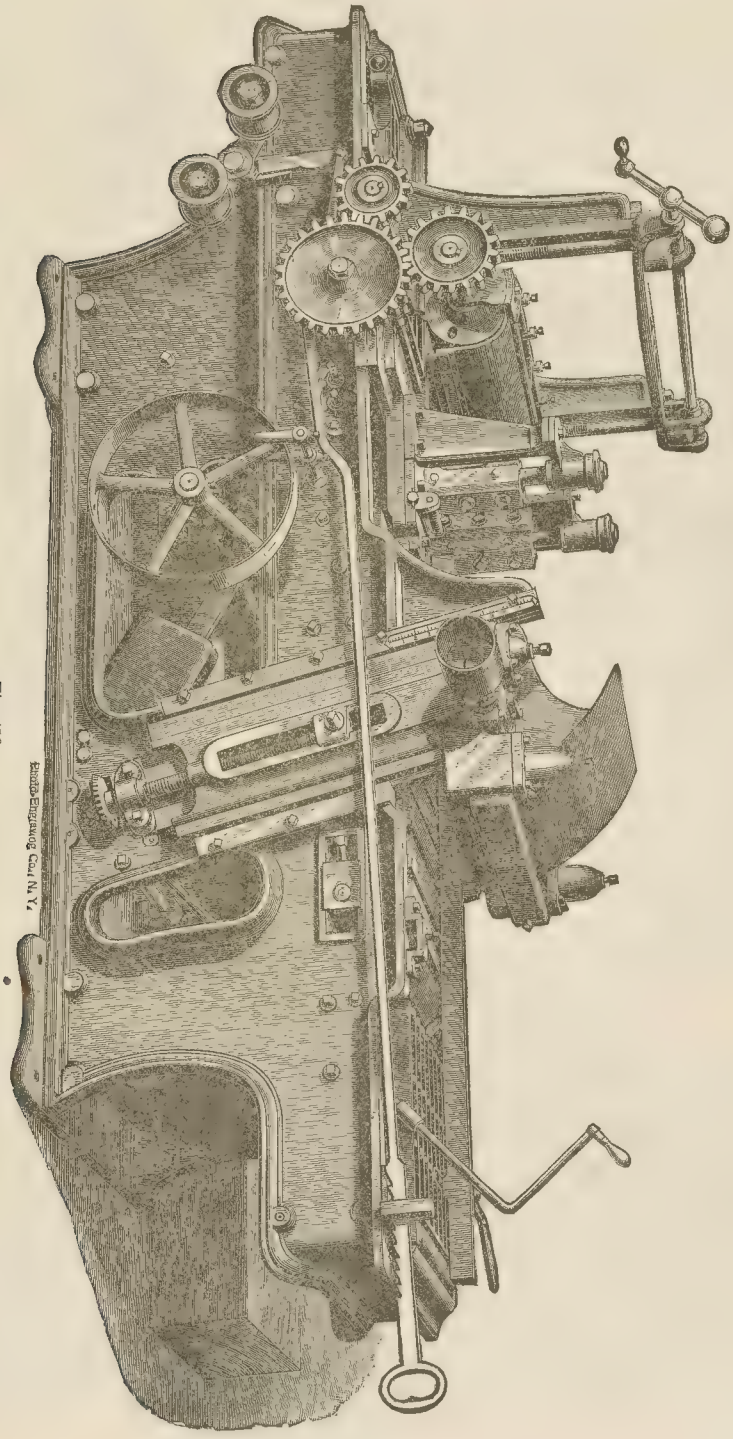


Fig. 456.

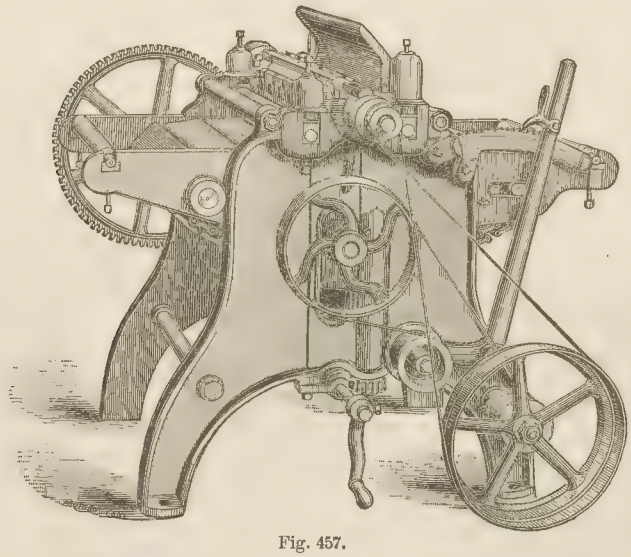


Fig. 457.

§ 45.

BUZZ-PLANERS—HAND-PLANERS—HAND-JOINTERS.

In the tools of this class the wood is held by hand and presented to the cutting-edges. They are adapted for surfacing and for jointing all kinds of small and joinery work, and effect a notable saving of time in comparison with hand-labor. One of the chief special problems they present is to permit an increase of depth of cut, without unduly increasing the opening at the cutter-head.

Fig. 458 (see next page) illustrates the general appearance of these tools and a special device for securing a close fit around the cutter-head. The table is made in two halves, with the edge of the cutters just protruding between them. The work is pressed upon the tables by hand, and is guided by the fence. This will incline for chamfers and bevels. The two tables are swung above the pairs of short links, and the screws at each end lift and lower the tables as the links are made perpendicular or inclined. The edges nearest the cutter describe a curve which is nearly an arc round the center of its axis.

Fig. 459 shows a hollow-base jointer, where a parallel link device secures close approach to the arcs of the knives. Two hand-wheels are necessary, because the back table should always be in line with the top of the

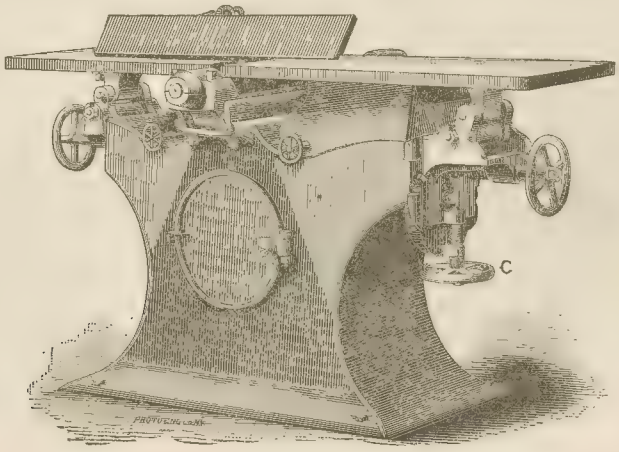


Fig. 459.

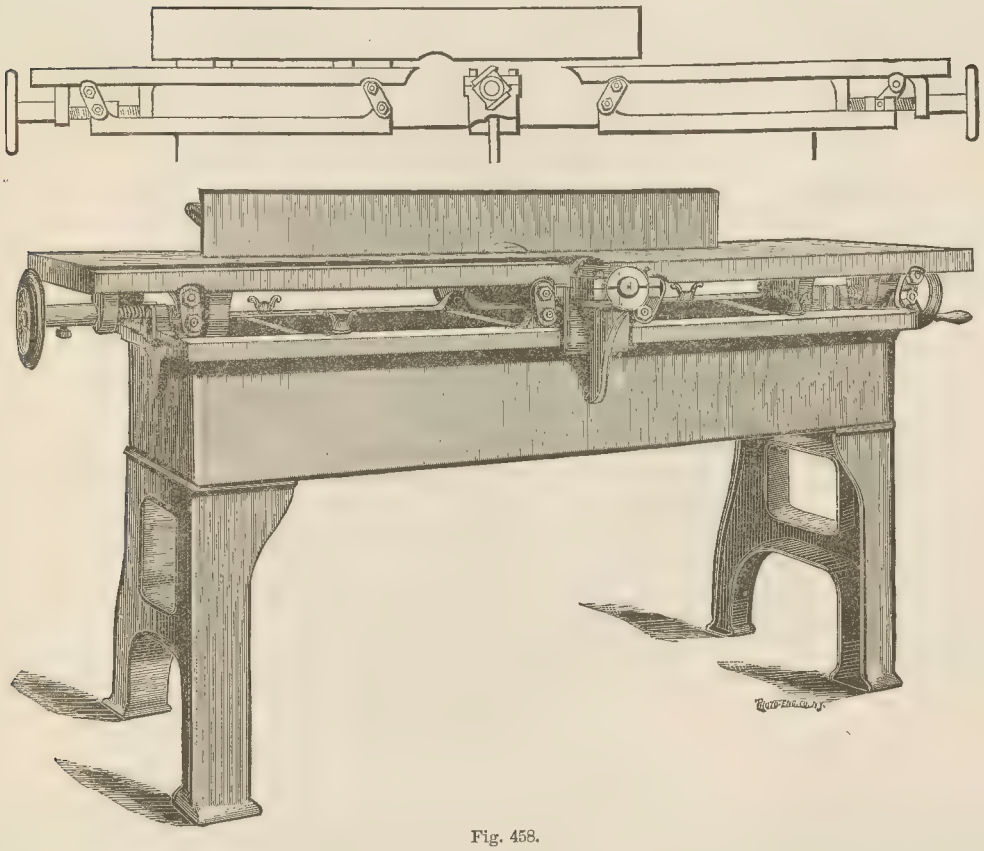


Fig. 458.

cutters. The depth of cut is gauged by the front table only. In order to make hollow or spring joints for gluing the front table is lowered by the hand-wheel C. When joints are planed hollow, the clamping of the glue-joint need be in the middle only.

Fig. 460 shows a similar design by the same builders, where the cutter-head stands at an angle with the direction of the feed of the stock. It is called a diagonal jointer. The shearing cut adapts the machine for cross-

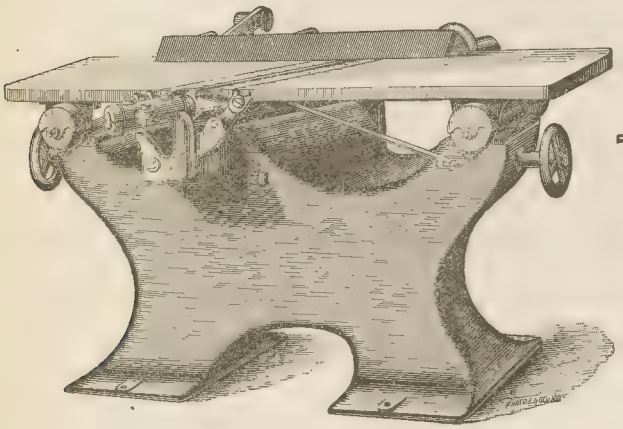


Fig. 460.

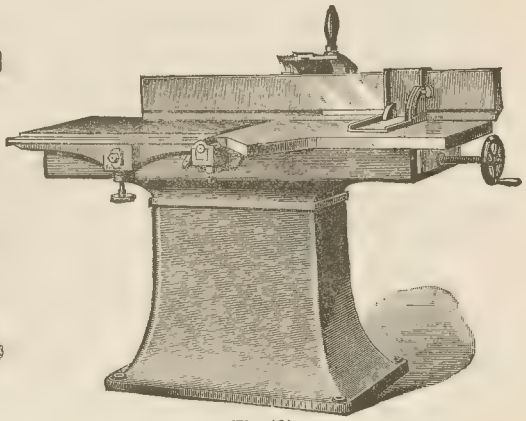


Fig. 461.

grained and curly lumber, and gives a smooth surface. In the planer of Fig. 461 the fence may be set at 45° to the vertical plane through the cutter-cylinder, and thus transform the straight jointer into a diagonal one. In this tool the danger to the hands of the operator when working on short pieces is overcome by the use of a finger guard. The tables rest on inclined planes, and their lips are faced with steel. The cutter-cylinder has three bearings, to secure freedom from spring. Some of the other forms of buzz-planer permit a horizontal tilt to the tables.

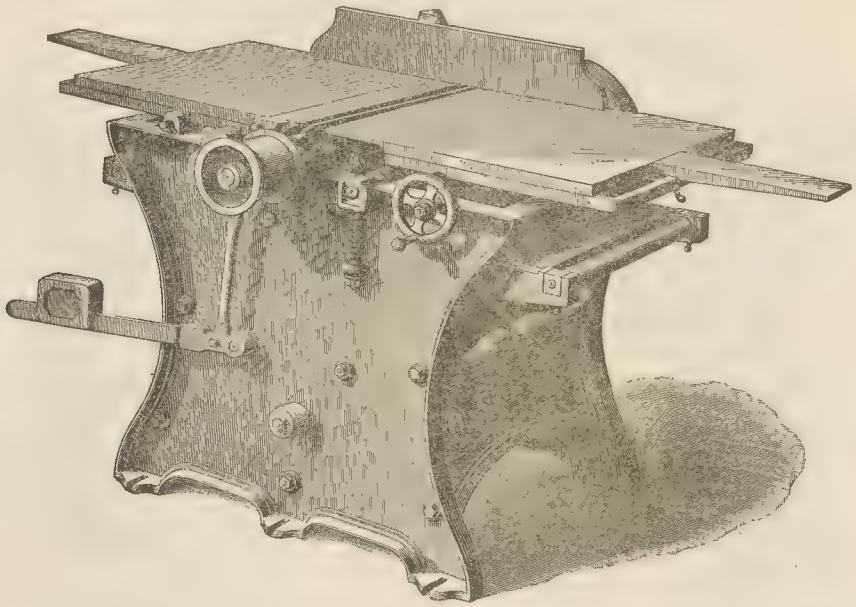


Fig. 462.

Fig. 462 shows a machine arranged to use the upper side of the cutter-head as a buzz-planer, and also the lower side as a pony surfacer. There are feeding-rolls driven by gearing-chain for the roll-feed over the lower table. The lower table rises and falls by screws, and Fig. 463 shows the expansion-gear for lower rolls. The front

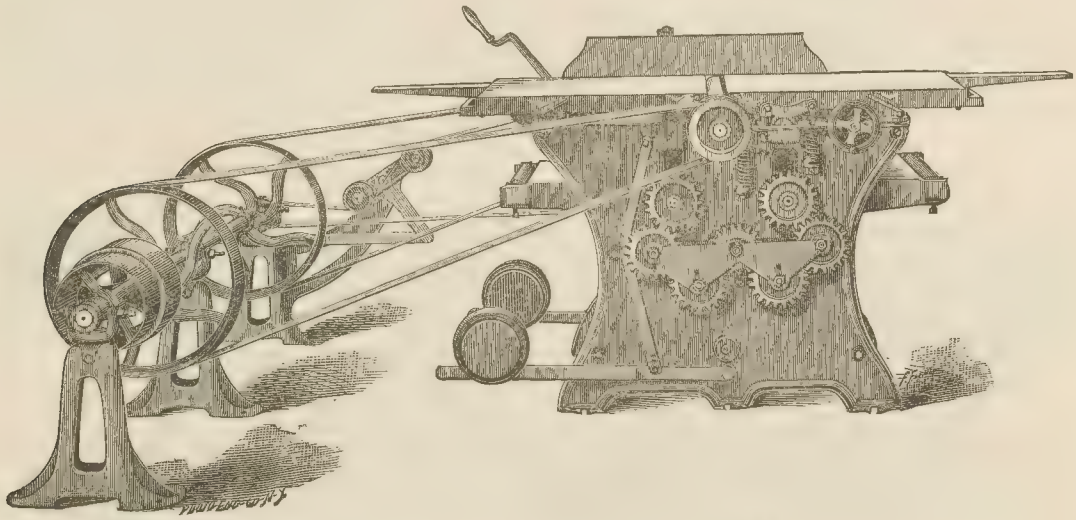


Fig. 463.

table for the hand-planer service is adjusted by hand-wheel. It makes a compact combination where both machines could not be kept full, or where both may not be required at once. As a principle, however, combination machines

are to be designed with great caution. The jointers previously discussed have been horizontal. For jointing small work, where finish is of moment rather than fit, a vertical machine such as Fig. 464 is approved. It is especially adapted for shingle-jointing and the like, and may be fed by two persons. The plane-knives make a drawing cut

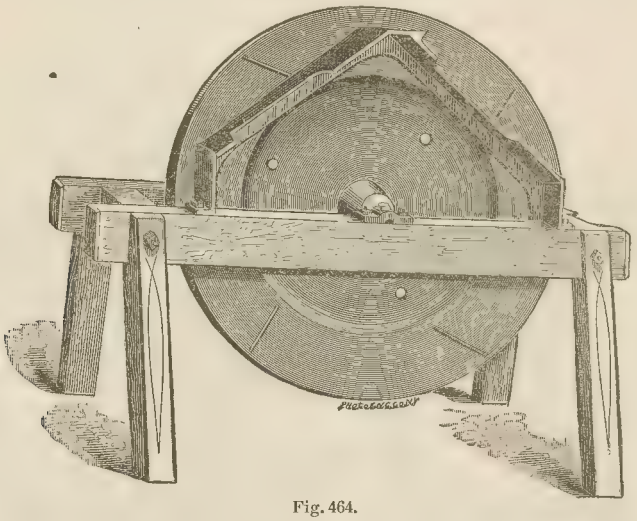


Fig. 464.

as they pass over and along the work. The stroke-jointer (Fig. 465) acts like a hand-plane, traversing back and forth over the work presented to it. It is, of course, adapted for edge work or more especially for jointing, and the stroke may be varied to economize time. The reciprocating knife gives a true and even surface. A knife on the

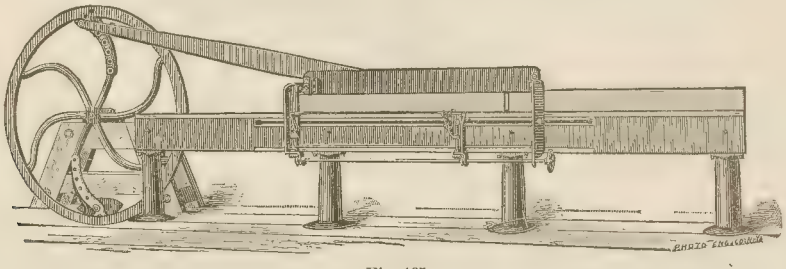


Fig. 465.

top of the plane-slide may be used for jack-planing. In jointing, the work rests upon the adjustable brackets shown. The tools of this class are finding an increasing application. Pattern-shops find them very useful for a great deal of their work. Better work is done on them when the pieces are heavy enough to help to resist the pressure of the cut.

§ 46.

SCRAPING- OR SMOOTHING-MACHINES.

To produce a smooth finished surface on hard-wood lumber which should show the grain it has been necessary to employ hand-labor. The surface has been scraped with a steel edge, slightly turned over into a shape not unlike the hook-scraper for metals. After this scraping process, the wood was ready to be filed and varnished. The scraping-machines of Figs. 466 and 467 *a* and *b* are designed to do by power that which has hitherto been done by hand. Fig. 466 is a small size in perspective, and Figs. 467 *a* and *b* show a larger size in end and side view. The scraper-knife is held stationary by a square holder in the lower table. The stock is fed over it by driven feed-rolls with expansion gear. The knife-holder is kept up by springs against bearing-screws, and the pressure of the lower rolls upward is also by springs. The upper platen and rolls are adjusted by screws together, worked by worms which are geared together in the larger size. The gearing is direct in the smaller. The lower hand-wheel, by compressing the lower spring, releases the stock or holder when necessary. The great obstacle in the way of these

machines hitherto has been the difficulty in securing the proper edge for the scraper. Although the machine has been on the market since 1857, the extended application of it has only begun since the introduction of the accessory machine of Fig. 468, for grinding and turning over the edge of the cutter. The cutter is securely clamped on a

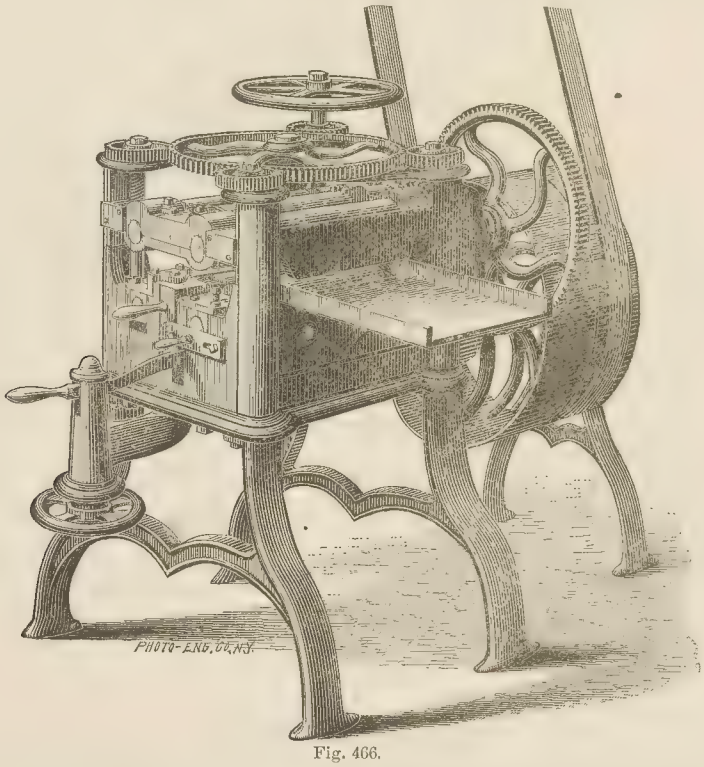


Fig. 466.

carriage, which slides back and forth upon ways under a pair of emery-wheels. The carriage is driven by a screw of steep pitch by open and crossed belts. There are two small emery-wheels, one acting on the face of the cutter,

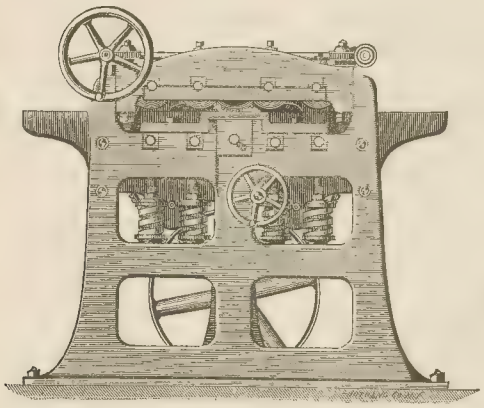


Fig. 467 *a*.

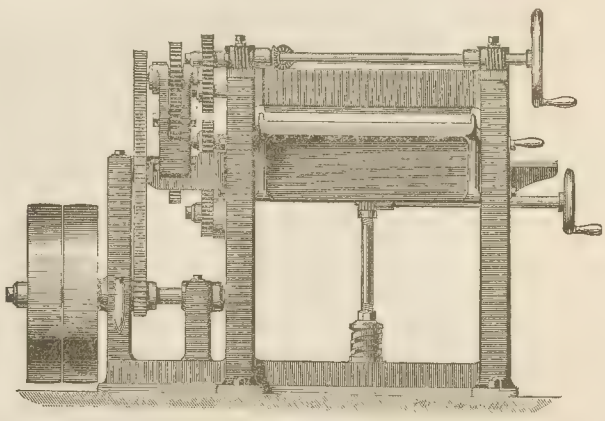


Fig. 467 *b*.

and the other in a different plane on the back. The rear wheel grinds a bevel of about 35°. After the edge is produced the emery-wheels are raised, and the burnishing-tool to the left of the emery-wheels is brought down to turn over the edge. The traverse is made by hand, and only once, while the the contact is lubricated by sperm- or lard-oil of heavy body. Great care should be taken to keep a perfect surface upon the burnisher. An exhaust-fan carries off the emery-dust from the bearing-surfaces.

The smoothing-machines are more especially adapted for the hard woods and for manufactured articles. They possess great interest as an instance of the direct replacement of hand-labor by that of a machine, with manifest gain in quantity and quality of work performed.

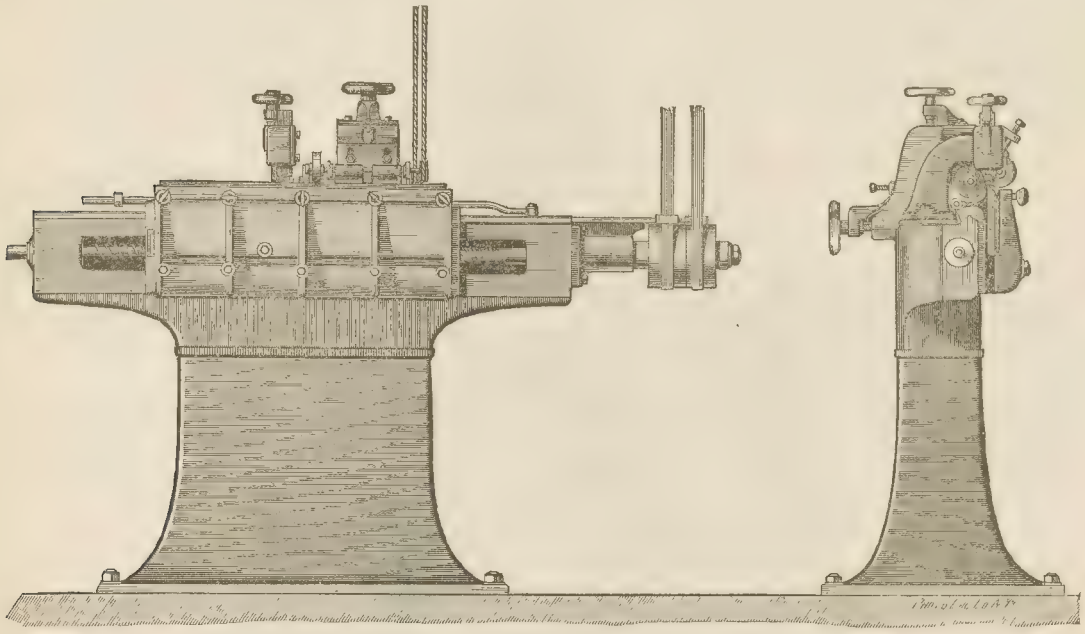


Fig. 468.

§ 47.

DIMENSION- OR CARRIAGE-PLANING MACHINES—DANIELS PLANERS.

The Woodworth planers, the roll-feed and lag-bed planers, belong to a class which might be called *parallel* planers. The upper and lower heads are not opposite each other, and each will act to produce a surface parallel to

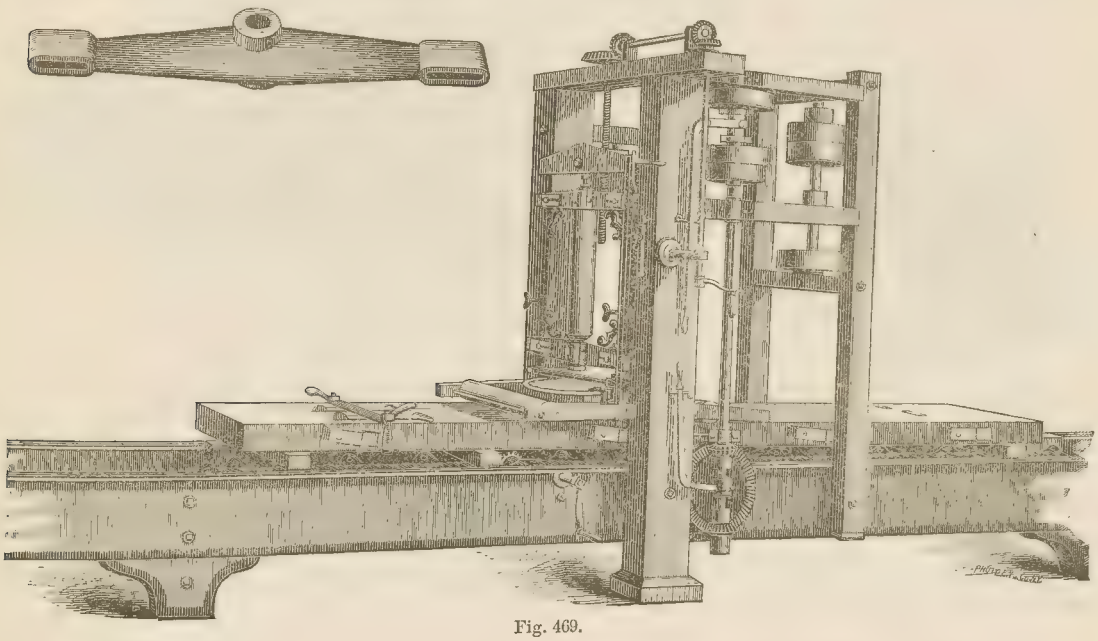


Fig. 469.

that which resists the pressure of the cut. This will be especially the case where the lumber is flexible, or where it is stiff enough to be in contact with the bed at a few points only. The resulting surface need not be a plane, nor need the finished stock be of the same thickness at all points of its length. Where the stock is to be true when planed, or of standard dimensions, it is necessary that it be dogged to a carriage which runs upon true ways. The passage of the stock under the cutters must generate a true plane surface on the top parallel to that of the ways. This one surface can be used as a base plane for working out the other three in rectangular work.

Fig. 469 shows the Daniels planer for this class of work, with wood frame. The two cutters are held in the ends of the arm shown in detail in the cut, and revolve transversely to the motion of the stock. This rotation is

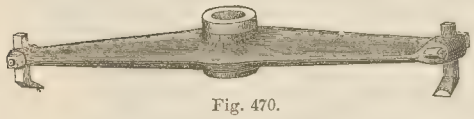


Fig. 470.

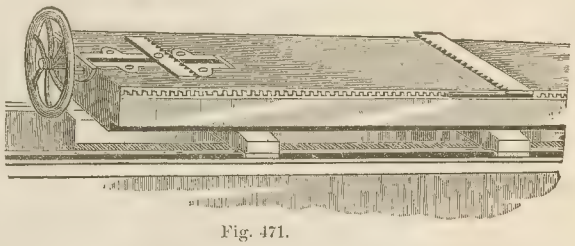


Fig. 471.

given to the long axis of the arm by a belt from a wheel behind, on a vertical shaft with fast and loose pulleys. Some designs use a drum at the back, arranged horizontally, and give the short belt a quarter twist. The cutters are borne in a sash-frame which is adjustable vertically by a screw for varying thicknesses of work. A cast-iron disk, known as the "dead-weight", hangs concentric with the cutters and serves to keep the stock to a plane when

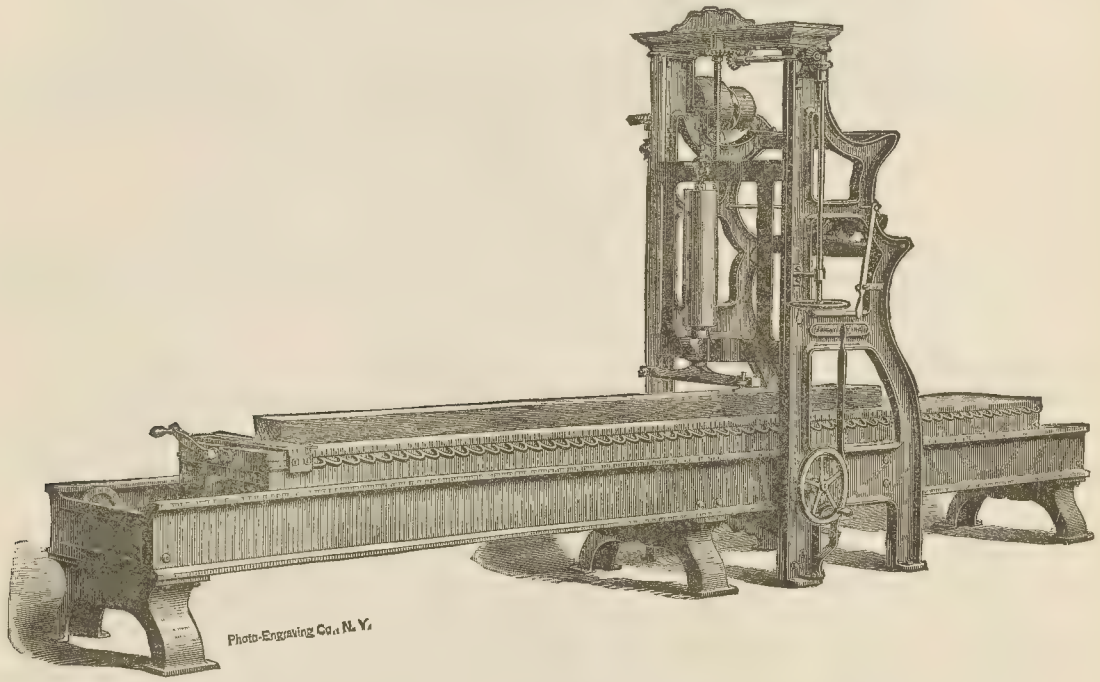


Fig. 472.

thin, and acts as a sort of chip-breaker also. A pressure-roll turns in a frame in front of the cutters. The carriage is fed forward by a rack in its under side. The rack is put below the driving-pinion, in order that there may be no tendency to lift the table. Motion is given to the driving-pinion by horizontal belts to a vertical shaft through a combination of two bevel-wheels and clutch. This makes it very easy by a motion of the hand-lever to arrest or reverse the feed instantaneously. A quick-return combination is secured by the upper clutch on the vertical shaft. For feeding forward the driving-shaft turns an idle shaft from which a further reduction is made to the gear-shaft, with choice of two speeds. For returning, the gear-shaft is belted directly to the driving-shaft, and with less reduction. The clutch engages the one belt or the other at will, independent of the reversing-gear below. A loose crank permits easy adjustment by hand.

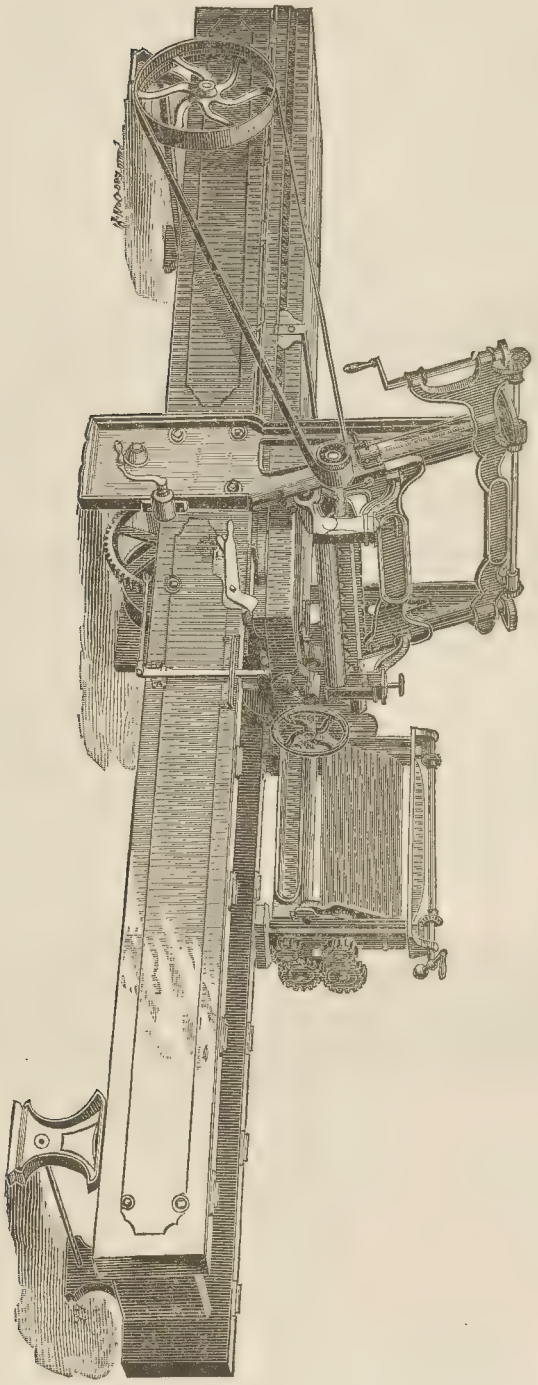


Fig. 473.

Fig. 470 shows a different form of cutter-arm with the usual cutters. The bolts have a hook-head, and the cutters come nearer to the ends of the arm. They also come central to the arm instead of in front of it, diminishing the leverage of torsion. For securing the work to the table, the cheaper device is by means of the toothed flats which are held in place by a clamped cross-bar. The toothed ends are driven into the end of the stuff.

Fig. 471 shows a screw-dog, where the serrated edge moves forward by the hand-wheel and the abutment only is adjusted for different lengths. It will be seen at once that the bed of the Daniels planer must be more than twice the length of the table, and the latter must be longer than the longest piece the machine is ever expected to accommodate. The great length of bed makes the machine a very bulky one, and has made many builders continue

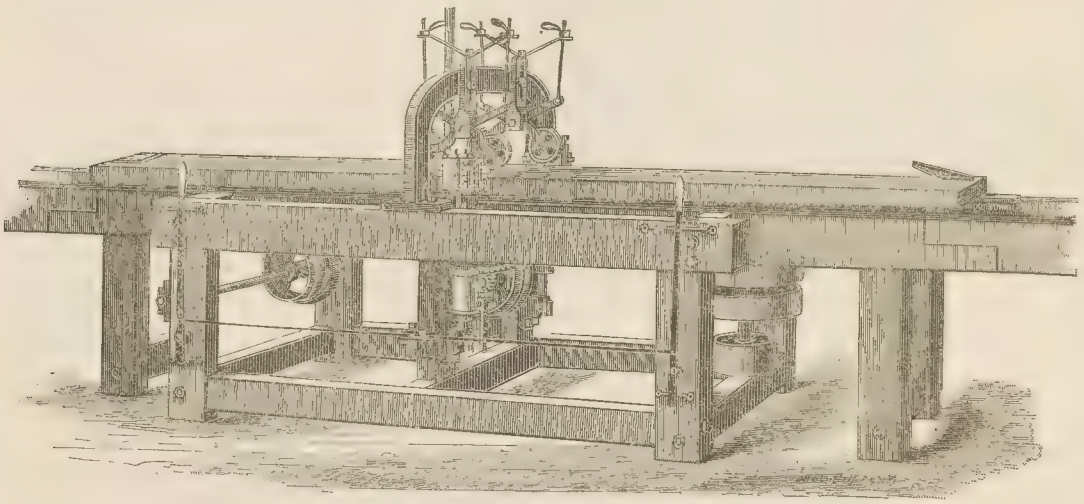


Fig. 474.

to make the framing all of wood. One or two are using iron uprights on the frame bolted to a wooden bed. There are objections to this, inasmuch as the wooden parts yield to atmospheric influences which do not affect the iron, and the excellence of their work is thereby vitiated. The high-grade machine is the one with metal framing, although its relative expense stands in the way of its extensive use.

Fig. 472 illustrates one type of the iron-frame planer, with the feed mechanism on the farther side. There are the same capabilities as in the other. While the transverse action of the cutters does not tend to distress or

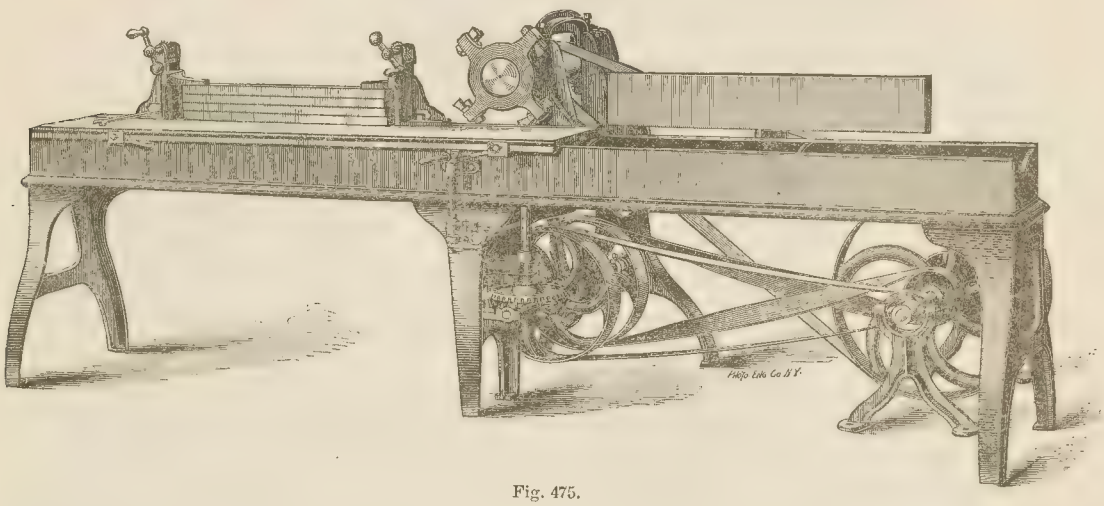


Fig. 475.

displace the lumber which is being trued, their action is slow. To remedy this difficulty, the rotary cylinder of the Woodworth planer has been fitted parallel to the traversing bed. It is made adjustable by screws for varying thicknesses and carries its own spring-pressure bars or rolls.

Fig. 473 illustrates a machine of this design. The adjusting-screws are outside of the uprights, and are geared to the convenient hand-crank. The machine will plane true and out of wind as well as the old, and has great advantages in the long life of the cutting-edges relatively to those of the transverse planer, and in the rapid feed. The same figure illustrates an attachment of feeding-rolls for the use of the machine on the pure Woodworth principle. The carriage being locked stationary, the stock is fed over it as in the typical machine. An iron plate which hinges up against the upper roll turns down upon the carriage to protect the wood from the wear of the friction of the stock. The roll-gear is hung upon a long hinge at the back, so that the operator does not have to lift its weight, and the rolls are geared to the feed-train by a special device. The passage, therefore, from a planer of one system to a planer of the other is made very simple and easy.

The principle of carriage-planing has not been extensively applied for double surfacing. There are but two or three such machines in service. Fig. 474 illustrates one of these for double surfacing or matching. The rotary cutters are opposite each other, and adjustable spring-pressure rolls keep the stock down while the dogs hold it from endwise motion. The feed-motion is very simple. A machine of iron frame, with a third cutter-cylinder lying horizontally across the bed, can surface three sides at once with corresponding gain in time. The principle of Fig. 475, which has a Daniels head with four knives on its side, may be doubled for double surfacing. The machine shown is designed for jointing, but can be applied otherwise. The thrust of the work is borne by a thrust bearing in the grooved surface of the babbitt. The reversal of the feed is effected by stops at the side of the carriage. It is no doubt the comparatively slow feed of the Daniels planer which has caused its slower development than the parallel classes of planers. While the earlier speeds of less than 20 feet to the minute are much exceeded to-day, the limited capacity of the machine has restricted its use to the shops which handle larger and heavier sizes of lumber for car, bridge, or other engineering purposes.

§ 48.

MOLDING-MACHINES—STICKING-MACHINES.

The paring-machines of the previous discussion have been intended to produce plane surfaces. The next class includes those which act to produce profiles or ornamental cross-sections at right-angles to the length of straight stock. These diversified cross-sections will be produced by rotating cutters or knives whose action is identical with that of the surfacing- or matching-heads of the planing-machines. In fact, many kinds of molding with flat top and bottom, and profiled only on the edges, may be made on any matcher by the exchange of the matching-cutters for those of suitable profile.

Fig. 476 illustrates a standard type of internal molding-machine for working molding-stuff upon four sides. It differs in width from the planers of the same builders, but has the same mechanical excellences. The stock must be guided laterally to secure a straight and uniform profile, and these are provided to be set at any part of the table. The lower head surfaces the base of the shape, and is a plain straight knife. The upper and side heads carry knives ground to the desired profiles.

Fig. 477 shows a number of types of head which are in use for a variety of purposes, with the knives in place. The side heads have lateral adjustment by screws for widths, and the boxes of the upper head have an endwise adjustment to bring the knife-profile exactly where it is wanted relatively to the other two. This may also be done if required for the lower head. The adjustment is by screws.

Fig. 428, of the planers of the same make, shows how the side heads are clamped to a round bar to prevent back-lash or tremble. The cylinders of molders usually are fitted with balance-wheels to equalize the motion when the knives are not symmetrical with the cylinder. The cylinders have two or four sides, for better equilibrium. A special form of pressure-bar is required to hold down the moldings after their tops have been shaped. Adjustable hinged cross-bars are fitted with a foot, which ends usually in a wooden sole, complementary in shape to that of the molding. These feet can be adjusted laterally and vertically upon the cross-bars, and thus steady the work beyond the cutters. Where the moldings are worked from rectangular stock the first rolls and bar may be straight and of the planer type. A notable economy in chips and lumber may be effected by previously sawing the stock into an approximation to the required cross-section, the saw-kerf perhaps entering the two sides of the squared stock at different angles.

The heavy black line of Fig. 478 represents the one kerf by which two molding-blanks are separated and the work of the molding-cutters is lightened and lumber is saved. For blanks of this sort a sectional pressure-bar is a feature of this manufacture.

Fig. 479 shows a sectional view of the cutter-head, with a number of separate feet resting upon the various parts of the profile. Such pressure comes near the cut, and each, being weighted, acts to help to cause smooth work. By the use of a number of heads with separate or sectional cutters on each (Fig. 480) it is possible to work out quite varied patterns. Each knife finishes a part of the profile in succession. By having the side heads adjustable laterally below, the crowns of moldings may be cut with a knife of durable shape. Projecting fine points in a profile are apt to burn off. Such a picture-molding as Fig. 480 in older practice would have been

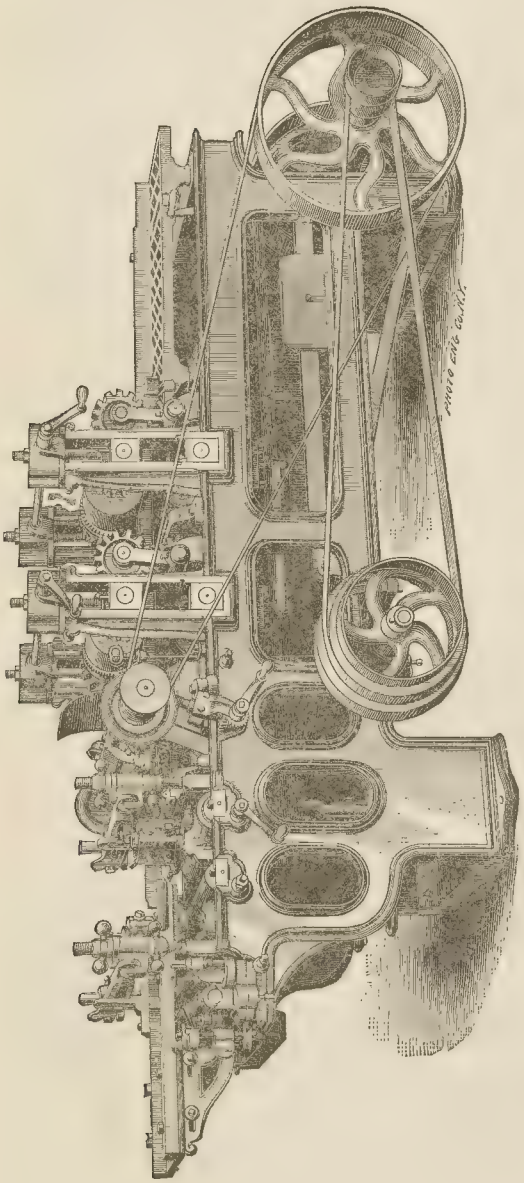


Fig. 476.

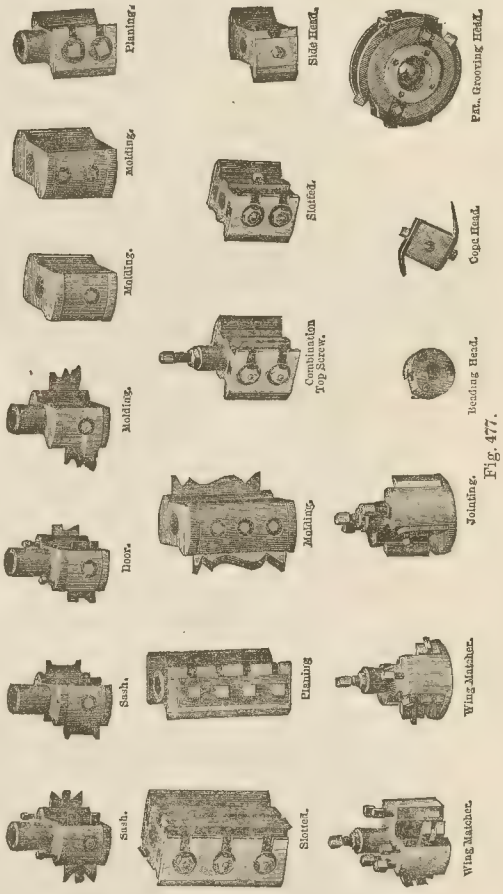


Fig. 477.

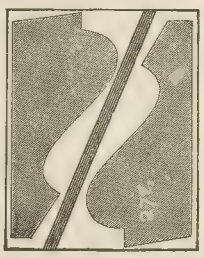


Fig. 478.

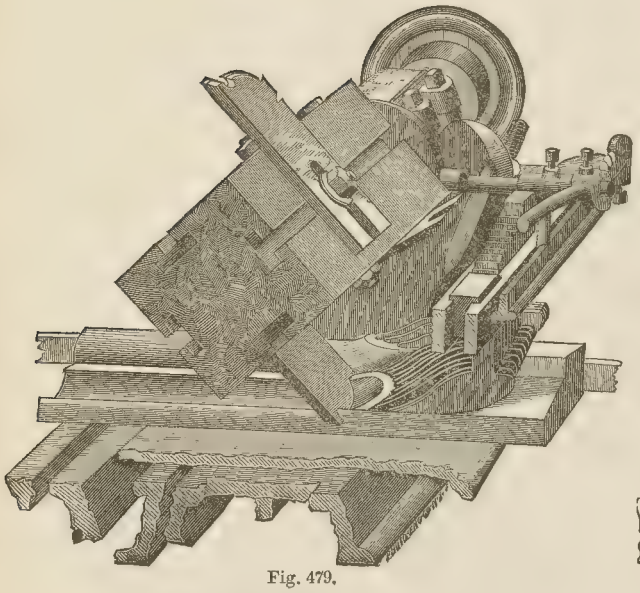


Fig. 479.



Fig. 480.

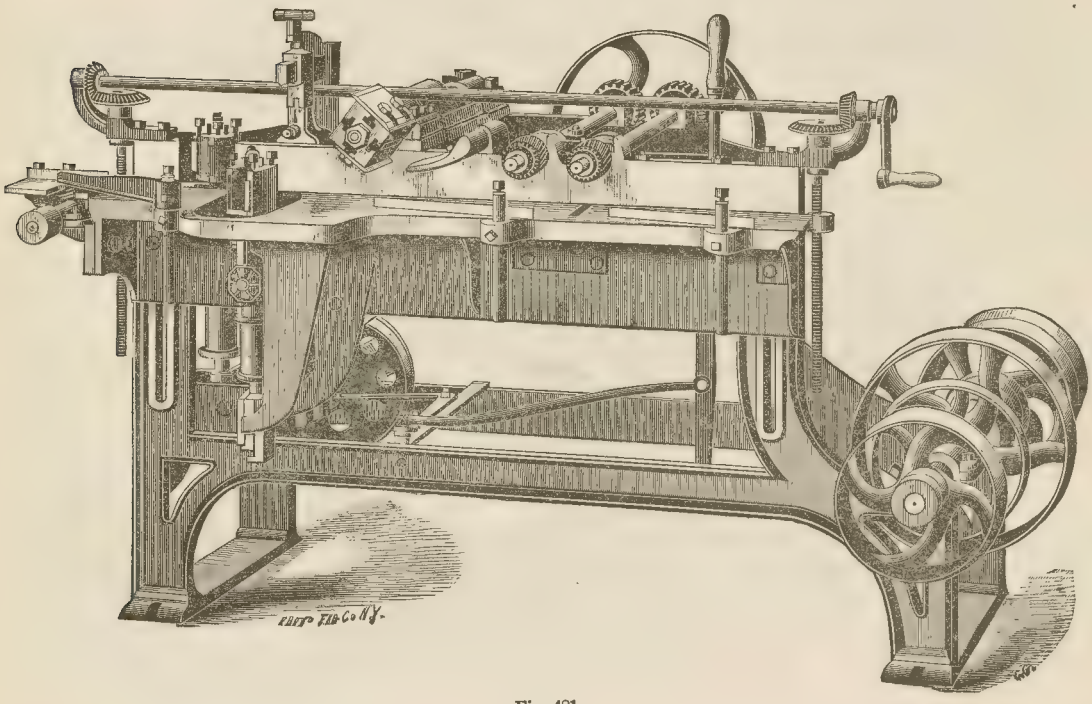


Fig. 481.

made in two pieces and glued together with a tongue. There are many classes of shops for which this type of inside molder has advantages. They will surface and match, if required, usually up to 10 or 12 inches wide, and may be used for ceiling- or flooring-stuff as well as for moldings. But on account of the greater accessibility of the heads for adjustment and for sharpening, what is known as the outside molding-machine or "sticker" is preferred, where the surfacing duty will be for narrow work only.

Fig. 481 shows one type of such a machine especially designed for sash and blind or similar work. As in all machines of this external class, the upper cylinder is stationary and the other three are attached to the table, which rises and falls by geared screws. The side heads adjust vertically and laterally, and there are take-up devices at

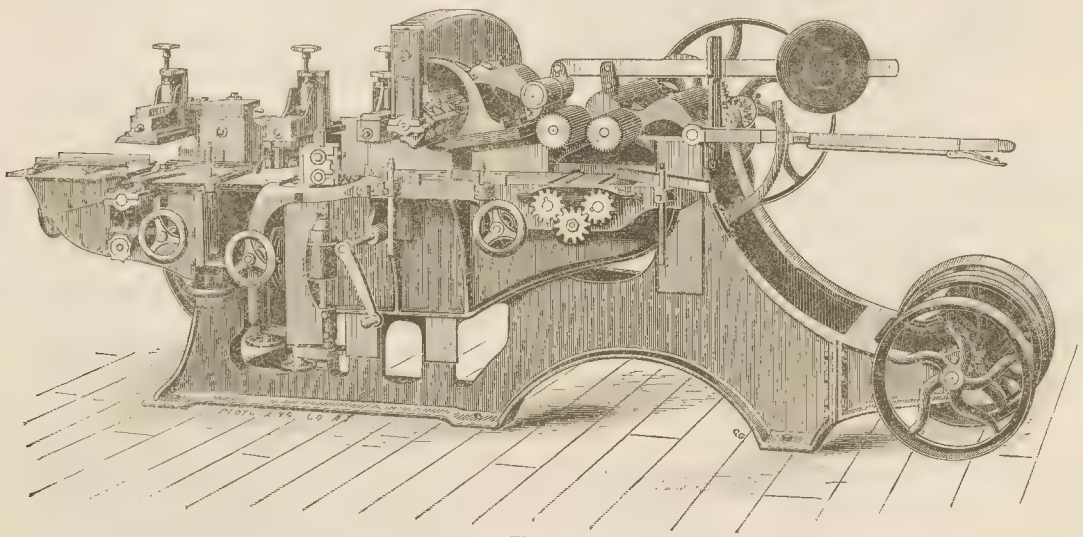


Fig. 482.

the foot for angular motion and to prevent chatter from wear. There are two pair of rolls driven by power engaged by friction-clutch below the table. These give a strong feed, and the upper rolls are fluted with spiral grooves, which tend always to feed the stock against the side of the frame which acts as a guide. There are springs adjustable in lugs in the table to keep the stock firmly in line and in contact with the frame. A solid pressure-bar and chip-breaker lies in front of the upper head, and an adjustable one with a foot holds the profiled stuff for the

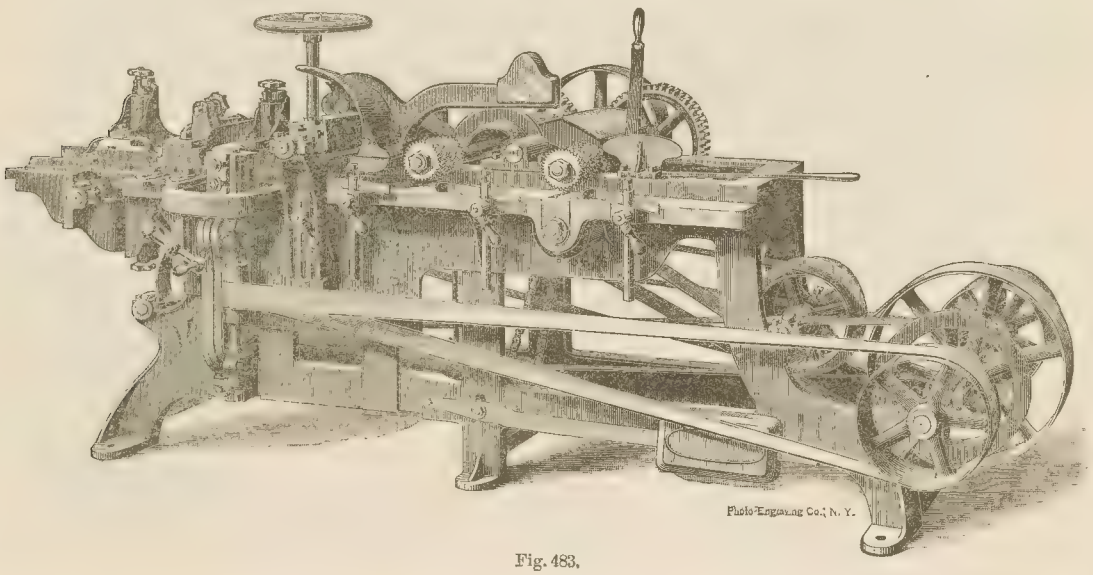


Fig. 483.

side heads. These latter are not put opposite each other, in order that there may be no danger if it is desirable that the cuts of the two sets of knives should overlap. The machine shown has the upper head overhanging. This is wise and possible for narrow machines. Where the work is to be heavier and wider the outer end of the spindle should be supported.

Fig. 482 shows a machine for molding 10 by 4 inches, with the spindle supported by an arm overhead. This system leaves the table free at the side. The feed-rolls are heavily weighted and fluted, all the rolls being driven. There are three pressure-bars, arranged with holders for sections of wood to fit the profile. A chip-breaker is in place in front of the upper head. The side heads have all the usual adjustments, lateral, vertical, and angular. At the further end of the table, beyond the under cutter, a section of the table is made adjustable, and is arranged so that a diagonal smoothing-knife may be mounted at that point. Beside the heavy gibbed slides for steadying the table, the ends may be bolted to the frame by a screw-bolt in a slot. The lifting-screw is geared to a horizontal shaft coming out in front. The counter-shaft is bolted to an extension of the bed-plate.

Fig. 483 shows the type where the outer bearing of the head is attached to the table, which must rise and fall behind it. The upper rolls are of a spur-tooth or serrated profile, arranged to lift perpendicularly. The lower

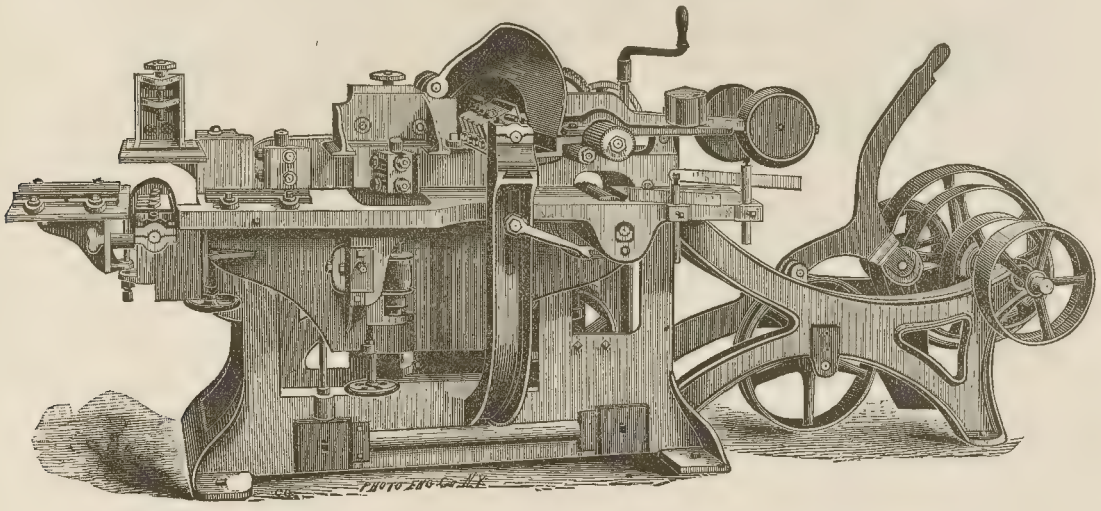


Fig. 484.

rolls are smooth, and are also driven. The upper rolls are so hung upon a crane-like frame that they may be lifted from the stuff by a lever at the rear if desired to arrest the feed. The use of gearing-chain is to be noticed. The shaving-bonnet and pressure-shoe are pivoted in front of the cutter-cylinder so as to follow the knives closely, and can be swung entirely clear for access to the cutters. The lower cylinder has a separate vertical adjustment independent of the bed, so that its cut may be varied without shifting the knives. The upper cylinder-boxes are held in a gateway, which is gibbed to the frame for easy lateral adjustment. In Fig. 484 the outer bearing is supported from below the table, and independent of it. The bolt in the slot gives additional security. Its other features are sufficiently obvious. The molding-machines of this class are specially adapted for shops which make a specialty of builders' moldings, and require to turn them out in large quantities. This work they perform very rapidly and very well.

§49.

UNIVERSAL WOOD-WORKERS—VARIETY WOOD-WORKERS.

The growth of small wood-shops at distances from the large centers has made a demand for a machine which shall have many other functions beside that of turning out linear moldings. To these the name of universal or variety wood-workers is given, on account of their large capacity for different kinds of service. One side is made entirely independent of the other, so that there are really two machines. One side is known as the molding-side, and the other half is called the wood-worker side. Fig. 485 shows a perspective view of such a machine, and Fig. 486 illustrates the molding-side. There are *five* heads in use at once, of which two act upon the upper side. These may divide the cut if it is heavy, or one can be used to take out dirt and make a rough cut, while the second finishes the upper surface. The lower head acts first at the front to plane the lower side of the material smooth

and out of wind before it reaches the molding-heads. The side heads rise and fall with the table, and have separate adjustments horizontally, vertically, and at an angle. A pressure-bar with wood foot lies between the two upper heads, and the shaving-bonnet may swing out of the way of the knives. Four of the cutter-heads have helical cutters, giving a dragging or shearing cut. The fifth is parallel and slotted. The feed-rolls are serrated,

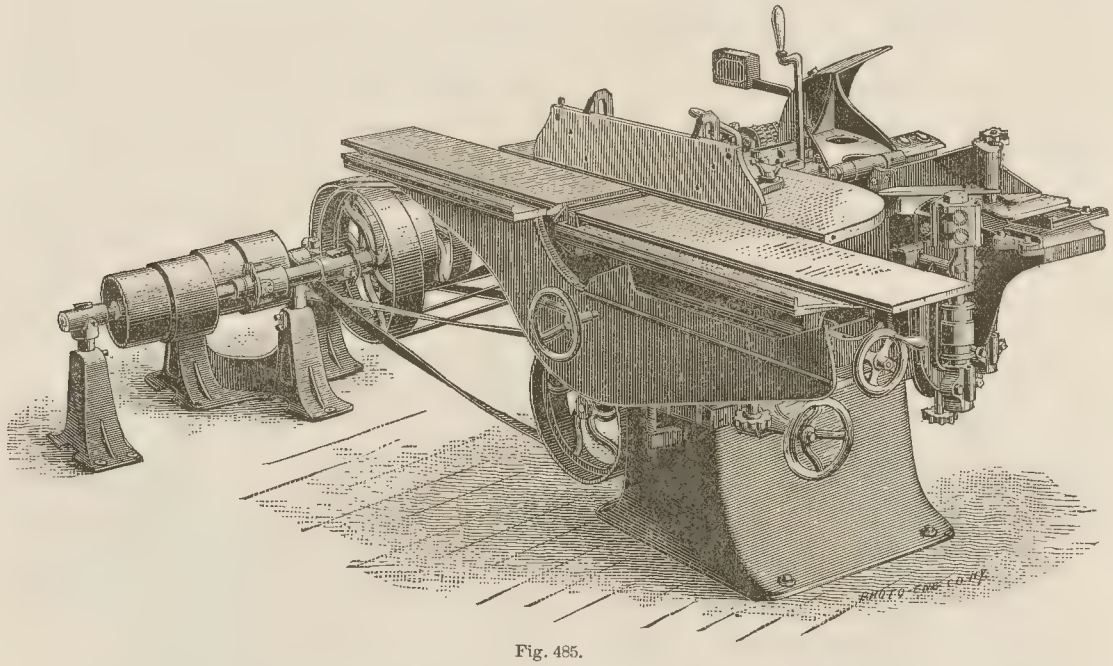


Fig. 485.

and are kept to their work by weighted levers. The form of platen for the outgoing end is more plain in the previous cut. The construction of the wood-worker side is essentially like that of a buzz-planer. The whole table

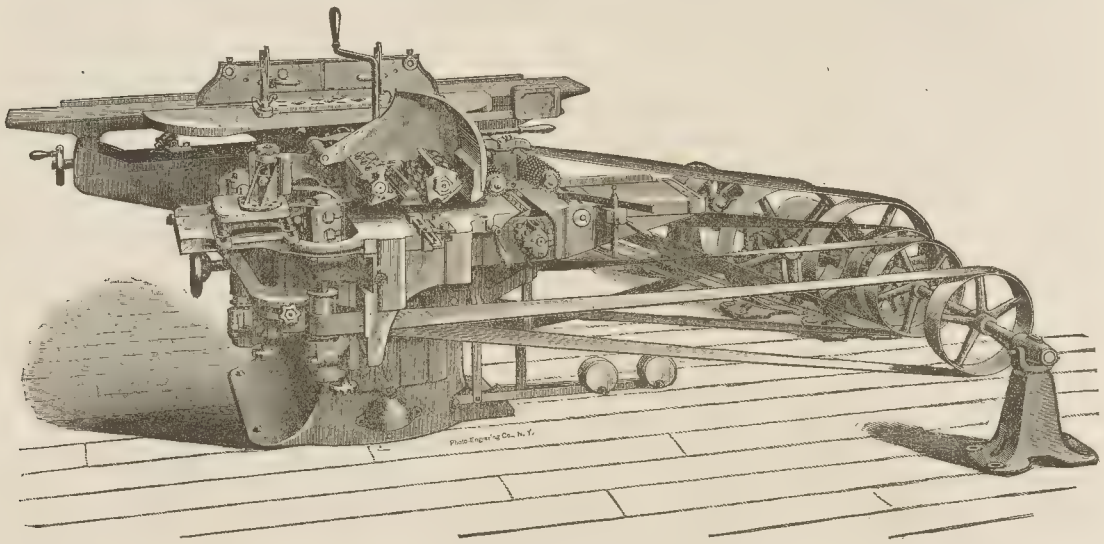


Fig. 486.

lifts and lowers by screw and hand-wheel; each top has a horizontal motion to and from the cutter-head, and both tables have a vertical adjustment on inclined planes by screw and hand-wheels. The two tables may be brought



Fig. 487.

together over the cutter spindle to guard against accident, and their accidental motion is prevented by thumb-screws and a rack with special pawl. The fence gives wide capacity for chamfering and bevels. The plate (Fig. 487) shows twenty-four different positions or applications of the machine. The numbers indicate respectively:

1, 2. Tables slide laterally, raise and lower, recede and advance toward the cutters.
3. Planing out of wind, jointing, squaring and smoothing.
4. Beveling, cornering, and chamfering.
5. Chamfering between the ends.
6. Cornering with chamfering form.
7. Tapering.
8. Mitering.
9. Rabbeting head and iron.
10. Rabbeting.
11. Tenoning.
12. Rabbeting and jointing blinds at one operation.
13. Panel fence, iron and head.
14. Panel-raising, both sides at one operation.
15. Tonguing, grooving, hand-matching.
16. Rolling-joints.
17. Making two plows at one operation.
18. Serpentine and waved molding.
19. Planing and fluting banisters.
20. Ripping and splitting.
21. Cross-cut sawing.
22. Gaining at right angle.
23. Gaining at any angle.
24. Circular, oval, and elliptical moldings.

These operations are permissible without adding special machinery to a fundamental machine. It is only necessary to mount the proper cutter-head and to adjust the fence and tables. Their universality has made them very popular, especially where the amount to be done of certain classes of work is too small to pay the interest on a special machine. This is likely to be the case in small shops and in small settlements. There is considerable variety in the forms of the universal wood-workers, although certain features must be retained in them all. An older design has a boring and routing table opposite the wood-worker side, and the latter can be rapidly changed from a wood-worker to a molding-machine for two sides by dropping the table. By fitting a proper head on the vertical spindle the machine may be used as a single-spindle shaper or friezer. It is made reversible by two friction-cones, engaged at will with a third between them by a foot-treadle. In one class of designs the cutter-head has an adjustable and removable outer bearing, as in the sticker of the same builders. A design of solid-frame variety of wood-worker, without the molding facilities which make it a universal machine, is shown by Fig. 488. The cutters

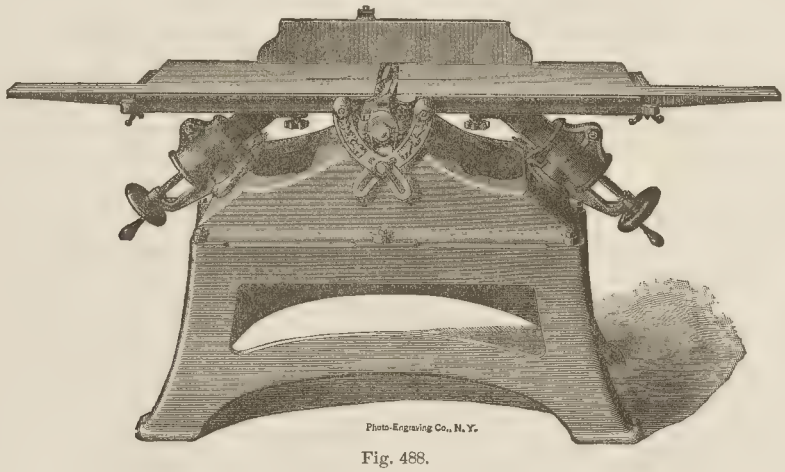


Fig. 488.

are helically arranged, and the two tables have separate adjustment by the plunger-bearings and screws. The head has outside bearings on the frame. Other designs have a columnar bed, with an arrangement by which the fence requires no separate adjustment. It retains its proper position relatively to the cutters by virtue of its

attachment to the forward table. It has lateral and angular adjustment, and may receive springs for holding down the stuff. When such machines are used for sawing, the usual tables are separated and a special one fits between them. Sawing is, however, not a legitimate use to which to put such machines. The broad scope of these universal and variety wood-workers adapts them to meet diversified needs; but where certain alternations would have to be frequently made, or where a certain class of work would keep a machine full and its operator busy, it is policy to have a special machine. Where, for instance, a quantity of tonguing and grooving is to be done to match small boards or tapering, such a machine as shown in Fig. 489 would be used. Taper or small work cannot

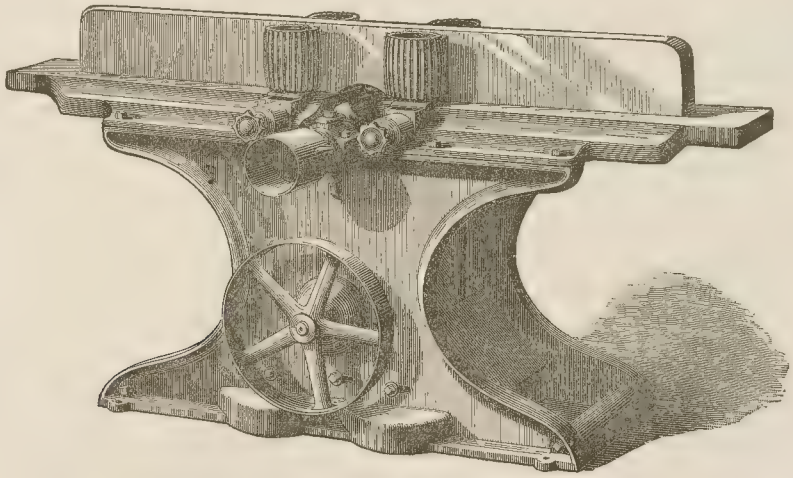


Fig. 489.

conveniently be matched in a large machine, and to do it on the wood-worker demands an entire change of head from that suitable for its usual functions. The same is true for panel-raising and edge-molding, to be discussed in the sequel. The machine of Fig. 489 has the central fence stationary, and the rolls and cutter-heads are adjustable horizontally for differing thicknesses of lumber. The rolls are heavily driven by gearing below, which is protected by the guards shown. Changes of feed can only be made by changing the large pulley below the cutter-axis. The fence carries friction-rollers, and the stock is fed in one direction to be grooved. It is returned in the reverse way on the other side of the fence, to be tongued by the other head. The feed may be by hand, if preferred. Such a machine may be found very valuable, either supplementary to the wood-worker or as a machine by itself.

§ 50.

EDGE-MOLDING OR SHAPING-MACHINES—FRIEZING- OR CARVING-MACHINES—PANEL-RAISING AND DOVETAILING-MACHINES.

Under this head is included a large class of machines which carry vertical spindles, fitted with rotary cutters at or near the top, which latter act upon their ends or sides. The machines are designed to produce profiles upon the edges of surfaces which could not be reached in the typical molding-machine. The edges to be profiled are often internal, and very often are curved, both of which conditions are prohibitory to the other type. Usually the feed is by hand, guided by formers or templets to which is secured the material to be operated upon. The templet bears against a collar on the spindle. These tools are very nearly on the line between the paring-tools and those which act across the grain also. Most frequently they act by paring.

Inasmuch as in a curved molding the grain runs in opposite directions on its opposite sides it becomes necessary to have either two spindles revolving in opposite directions or else to have the one spindle reversible. The latter is perhaps the newer practice. Fig. 490 illustrates the type which has long been standard. The two spindles are driven by quarter-twist belts from the counter-shaft at the rear. The pulleys on the spindles are very wide and crowning, and a flange at the bottom acts also as a balance-wheel. Instead of one upright, many builders make a framed bed, the spindles being supported on cross-girts between the two sides. The top may be of alternate strips of wood, glued together to prevent warping, or it may be of iron. In the design shown the lower box is also a foot-step. A steel foot-screw supports the weight and thrust of the bearing. The back of the box is of babbitt-metal. The front is of brass composition, which is slipped in place, and is held by a set-screw through the cap of the box. The spindles always have a vertical adjustment to bring the cutter-knives to the proper level.

The upper end of the spindle ends in a species of chuck (Fig. 491), by which two flat knives of the required shape may be held firmly by the central screws and the set-screws. Many firms are using solid cutters, which can be milled to the required profile, and are not as liable to the dangers which attend the flat knives. If a knife works loose in a spindle revolving at 5,000 revolutions, as these small ones may, the centrifugal force transforms it into a dangerous missile.

Fig. 492 shows a form of one of these solid cutters for edge-molding, and Fig. 493 shows how the cutter is freed between the edges to diminish friction and to give clearance to the cut. The dotted line shows the full

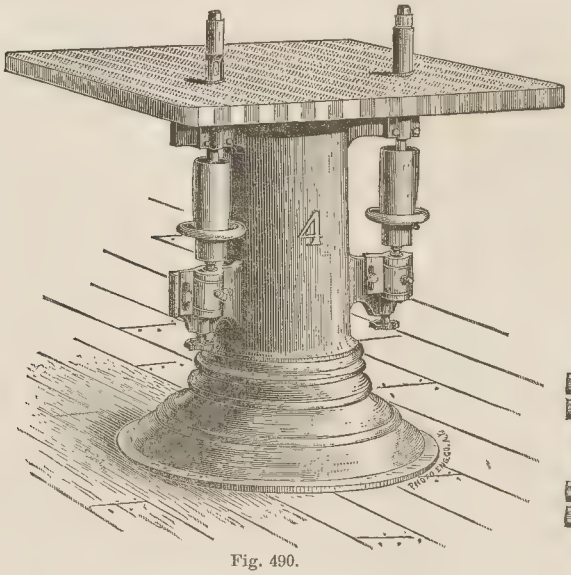


Fig. 490.

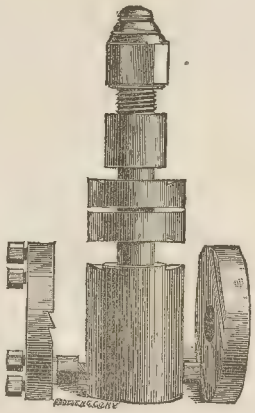


Fig. 491.

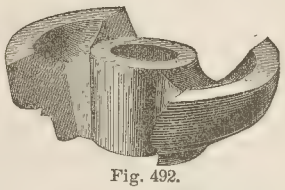


Fig. 492.

circular profile. Cutters of this type cut at all four edges, so that they may be reversed. They are a specialty of one of the carving-machine builders, and are milled from Pittsburgh steel. For the protection of the fingers in the use of the machine a cage or shield may be put over the spindles supported on an adjustable upright.

There are objections to the use of the quarter-twist belt. The spindles must run very rapidly, and since the pulley is small a wide belt is needed to prevent slipping. The counter-shaft, too, must be at some distance from the

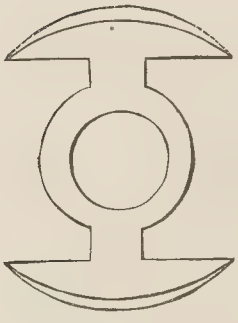


Fig. 493.

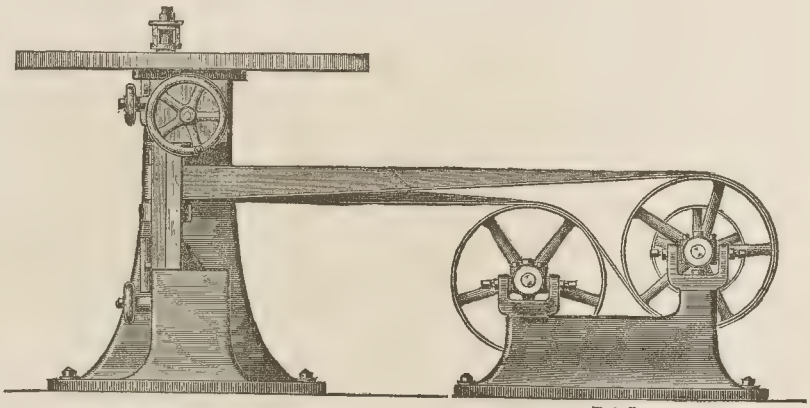


Fig. 494.

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machine, to avoid a very great strain and wear due to the twist in a short interval. The design shown in Fig. 494 in side view and in Fig. 495 in front view exhibits the use of large guide pulleys to cause the belts to approach the spindle-pulleys more nearly at right angles to their axis. The shaft-boxes are adjustable and swivel. The two spindles turn in conical brass journal-boxes, which are borne in a frame gibbed to the base-casting. These frames are adjusted vertically by inclined planes worked by the hand-wheels. The cutter-knives are held by compression from the nut above them.

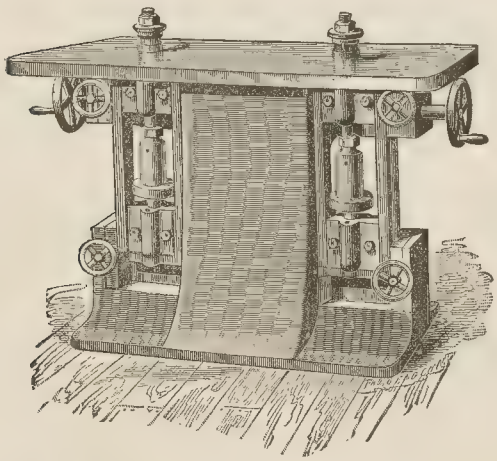


Fig. 495.

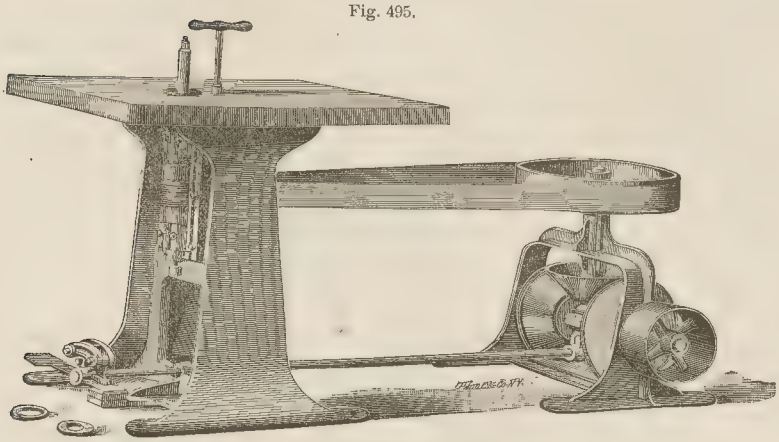


Fig. 496.

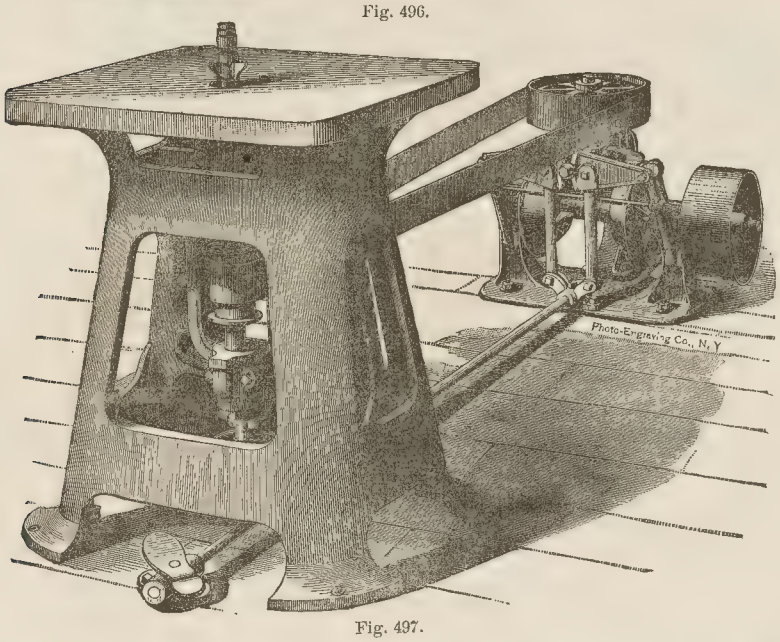


Fig. 497.

The western builders have sought by the use of a simple reversing device to secure the advantages of a straight belt and of a single spindle. Fig. 496 shows one of these designs. The loose pulley is dispensed with, and the vertical shaft may be driven by frictional contact with one or the other of the cones on the shaft. The foot-treadle turns the rocking-shaft and shifts the driving-cones into contact with the follower. The latter is an iron wheel; the surfaces of the other two are of paper or of glued tar-board. The spindle-gate is raised and lowered by the socket-wrench. The slides are of dovetail form. The lower bearing consists of a conical box inside of a cylindrical case, with step-screw at the bottom. The friction device of Fig. 497 consists of paper drivers and iron follower, the shifting mechanism having some original features. The cones are shifted by the foot through the torsional shaft, which throws the spiral sectors. They bear upon the roller upon the stud between them, and thus lock the levers. In another design by the same builders the two cones are on the upright shaft, and the reversal and arrest is effected by a rock-shaft, controlled from a handle at the left of the table. The spindle frame is double, of a ribbed section, and the bottom step is made adjustable and self-oiling. The frame has vertical and angular adjustment, for flat and deep moldings.

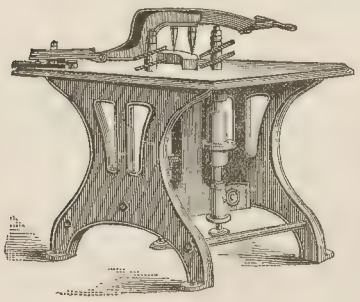


Fig. 498.

Fig. 498 shows a machine for shaping which uses saws set obliquely on the vertical spindles. The fine teeth do not cut or tear, but give a shearing or oblique action, which fits them for working against the grain. The illustration shows how arcs may be produced by the use of a machine of this class. The pointed holders are pivoted around an adjustable center.

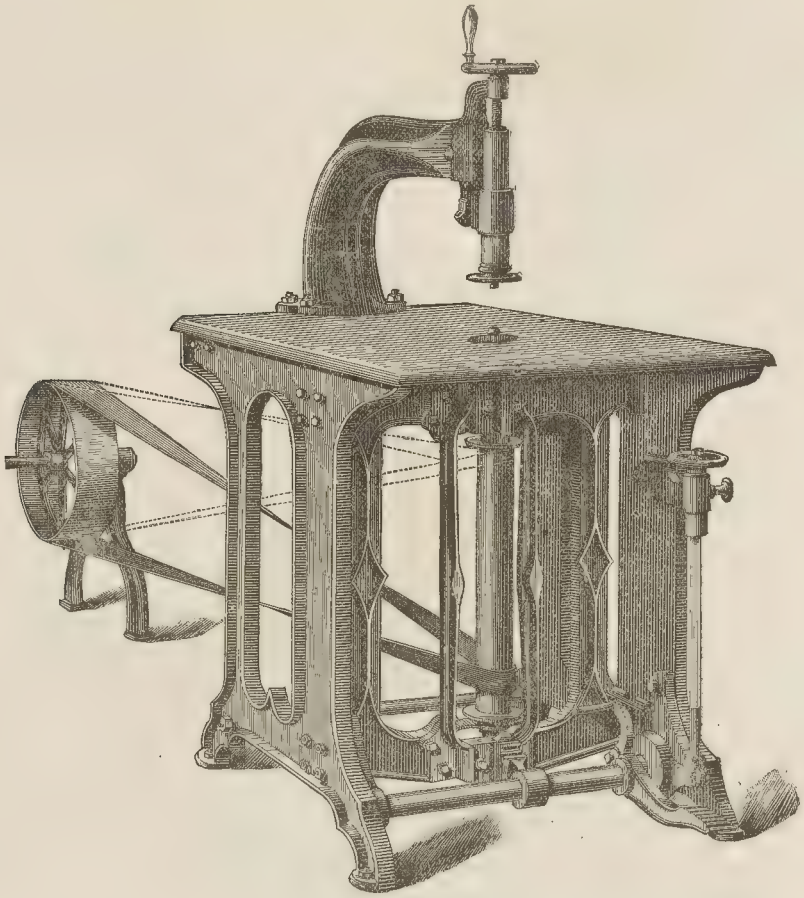


Fig. 499.

The machine of Fig. 499, while applicable as a friezer, is especially fitted for carving or for raising panels. The counter-shaft has open and crossed belts, and the spindle-pulley has to have a length greater than the diameter of

its driver to permit the quarter-twist belt to follow its tendencies when the counter-shaft is reversed. The newer machines have three cones, and avoid the twist. The work to be carved or paneled is secured to a former or templet, which is guided by the pin in the bottom of the pressure-plate on the upper spindle. This plate acts as a platen to resist the lifting action of the cutters. It is adjustable for thicknesses. The upper box of the spindle is babbitted; the lower journal has a brass box, with steel washer and step-screw. The feed of the cutter to its work is given by the foot-treadle, adjusted by the screw at the side, with suitable stops when the right depth

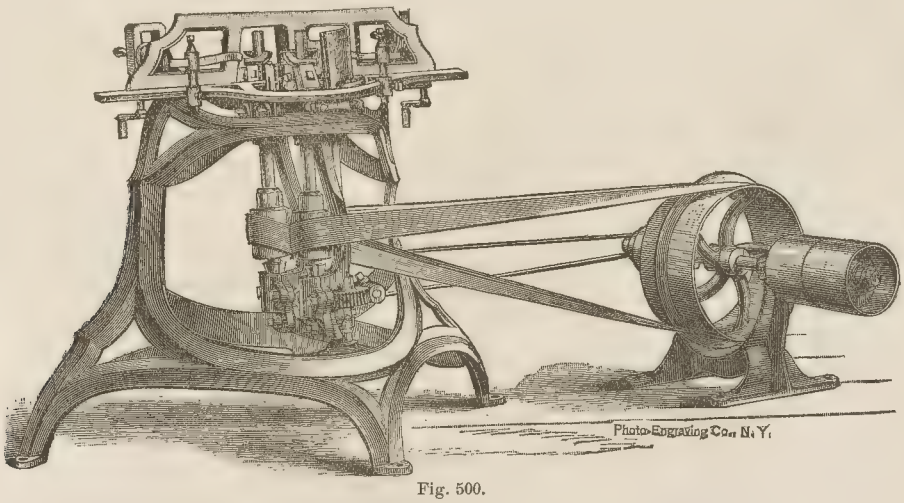


Fig. 500.

is reached. Upon the top of the table special attachments may be bolted for elliptica. molding and for bracket-molding. It is in this latter function that this tool finds a field to replace the jig-saw. A rotary mill replaces the platen, and is driven over guide-pulleys on the back from the counter-shaft. A tool of the type just described is the only one which can sink panels. For raising panels in relief the usual type of machine is shown by Figs. 500 and 501. There are two vertical spindles, one on each side of a guiding-fence. By the two spindles both sides

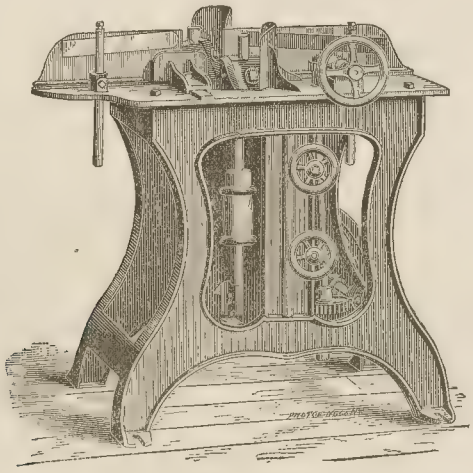


Fig. 501.

of stock may have panels raised on them or intricacies of grain may be provided for. The spindles are fitted with knives to produce a helical or dragging cut, and any profile for the edge of the panel may be secured by properly-shaped knives. The spindles are adjustable laterally for different thicknesses of panel-bed, and also vertically for different widths of panel. There is also an angular adjustment sidewise. Springs in suitable holders confine the stock to the fence. It is usually fed by hand; power feed-motion may be provided, in the shape of a spirally-corrugated roller in front of the cutters.

Panels may be also raised by the universal or variety wood-worker by the mounting of suitable cutter-heads. Where there may be much of it to be done, it is worth while to mount such cutter-heads separately, in order to avoid the temporary stoppage of the wood-worker in its more usual operations. Fig. 502 shows such a machine, built with a wooden frame. The shield for the cutters is shown detached at the foot of the table. The cutters are held in the head, so as to give an oblique cut, and both sides may be worked at once. Lateral adjustment of the cutter-heads and vertical adjustment of the table are required, and are both provided for. The removable knives render unnecessary what would replace the angular adjustment of the vertical spindles, and in respect to simplicity there would seem many advantages in favor of this latter type.

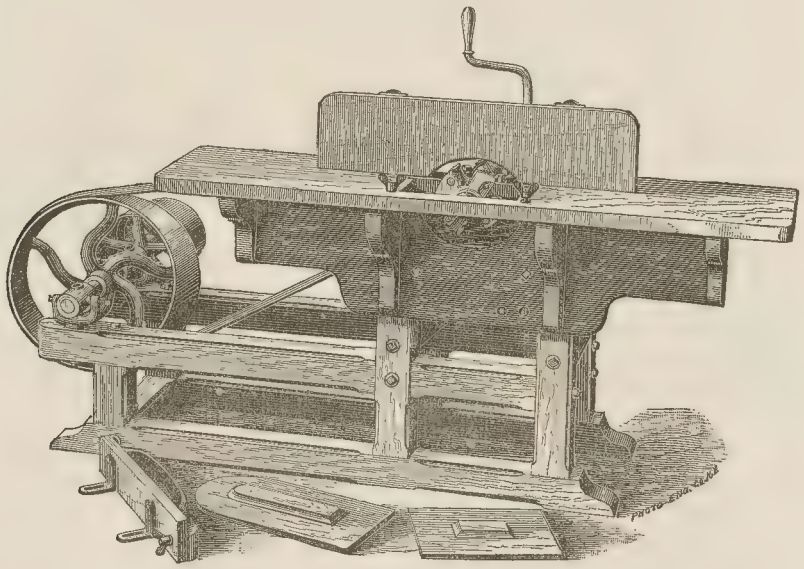


Fig. 502.

The adaptation of the friezer or carver for dovetailing is exceedingly simple. The spindle carries a cutter of the shape shown in Fig. 503, and by varying its size and shape every proportion may be secured for the joints. A simple clamping, feeding, and spacing carriage runs upon ways clamped to the top of the table, and cuts the front and side dovetials at one operation. Fig. 504 shows the attachment for the carver and molder made up into a separate machine, as it is judicious to do where it can be kept full and remunerative. The front and side are clamped in place, and are fed to the cutter by an arm with a sector. The edge of a spring falls into notches to

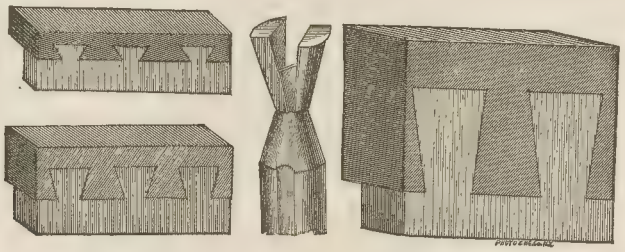


Fig. 503.

give equal spacing. The linear cutter insures the fit of the pins, since the edges of front and side are cut by the same lines. Thicknesses from one-quarter of an inch to 1½ inches may be dovetailed with equal facility. The mechanical features of its construction are the same as in the carver of the same builders. Fig. 505 shows a different from of a similar machine. This form of dovetail is stronger than the Knapp dovetail, with round pins made by a hollow auger, and superior to the Yankee dovetail, where the ends of the sides are left straight without being scalloped.

The radius-planer of Fig. 506 is an edge-molder with horizontal axis. The material to be planed and shaped is clamped to a pattern and presented by hand to the cutters which have the required profile. Such a machine, beside working crooked and cross-grained stuff, can be used as a machine spoke-shave or smoothing-plane for very narrow work. Forming-guides go with the heads of various profile, for cornering, chamfering, and rounding, and the machine may be made useful in many kinds of manufacture.

The tools belonging to this subdivision bear about the same relation to wood-working machinery that milling-tools bear to the metal-working tools. For irregular outlines upon curved shapes they fill a large field, and one of very great importance in wood-conversion by machinery.

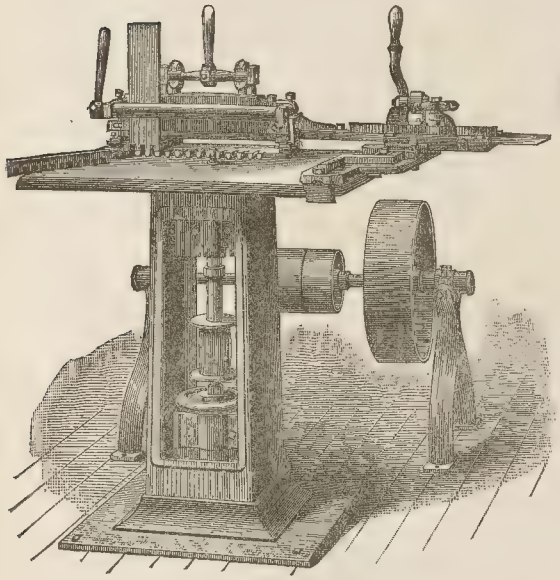


Fig. 504.

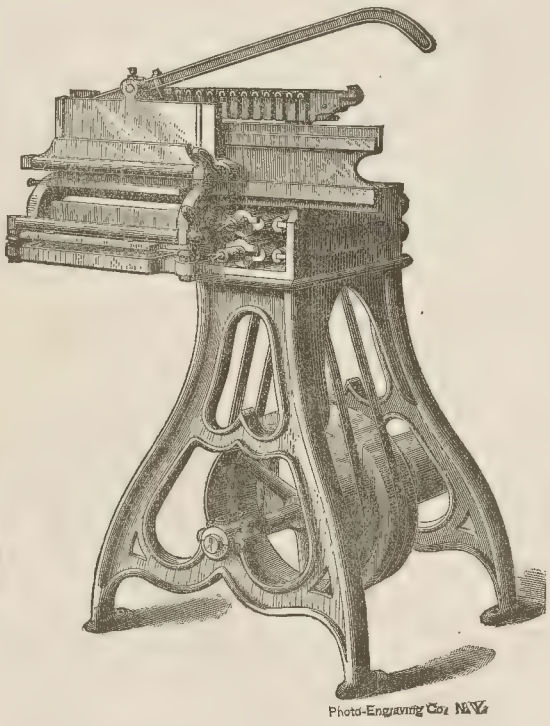


Fig. 505.

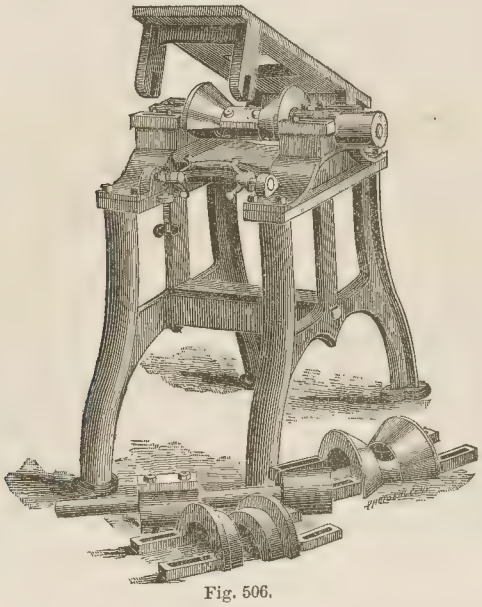


Fig. 506.

§ 51.

H.—TOOLS OPERATING BOTH BY SCISSION AND PARING.

WOOD-LATHES—GAUGE-LATHES—LATHES FOR IRREGULAR FORMS—DOWEL, PIN, AND ROD MACHINES.

Any tool whose cutting action is in a plane transverse to that to which the fibers are parallel must first sever them and then split or pare the severed fibers from the stock. In the paring-tools hitherto discussed at the moment of severing the chips the cutting-edge has been moving parallel to the axis of the material. The feed has been at right angles to the axis, around which the cutter-knives were revolving. In the remaining class the feed will be in a plane parallel to the axis of the cutters, and the latter will act at right angles to the axis of the material. The ordinary wood-lathe illustrates this. The work revolves with its fibers at right angles to the axis of the turning chisel. The latter is fed along the rest parallel to the axis of the cylinder which is being formed. The cutter must first sever, and then split or pare. Its action is therefore a combination of the two previous methods.

With respect to the ordinary wood-turning lathe there is but little to be said. All builders of wood-working machinery make the head- and tail-stocks and rests, leaving the purchaser to furnish the shears, which are very often of wood, with wood or iron legs. Fig. 507 illustrates a typical form. For the convenience of pattern-makers

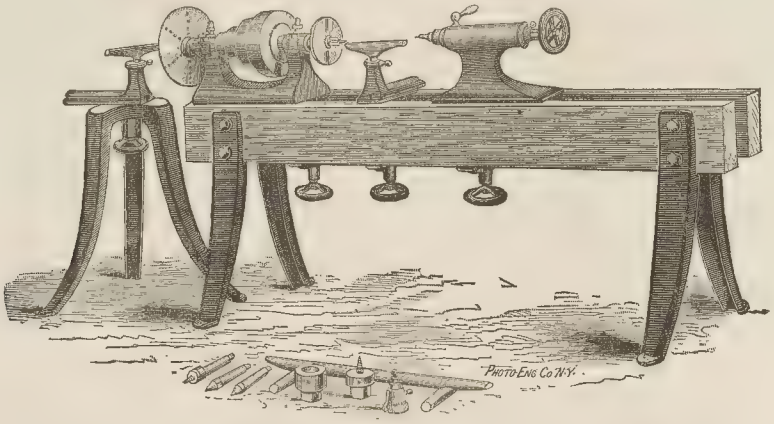


Fig. 507.

who may have large flat surfaces to chuck and turn the outer end of the head-spindle is made to accommodate a large face-plate, and a special tripod holds a second rest for facing large work. The lathe then has a swing equal to the height of its spindle from the floor. When the second rest is on the shears it may help carry the long double rest for long cylinders. The cone-pulleys are very often built up of mahogany for the sake of lightness at their high speed. The figure illustrates screw-clamps for tail-stock and rests. Very often lever cams or wedges are used. It also illustrates the prevailing arrangement of the nest of pulleys, with the largest nearest to the center. Fig. 508 shows an arrangement designed to give more freedom to the swing of long tools when working near the

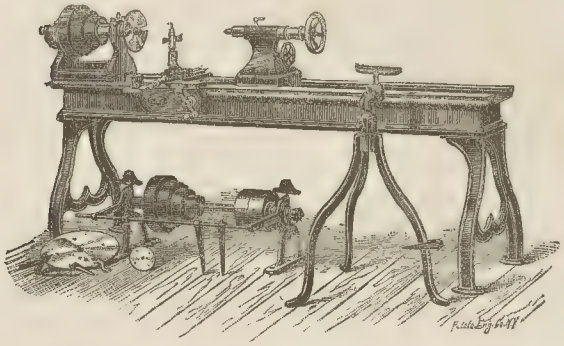


Fig. 508.

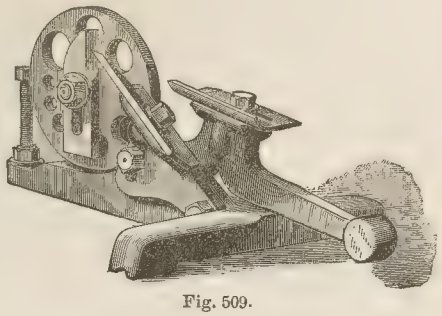


Fig. 509.

head. The cone is reversed, and has its largest pulley farthest from the center. This shows a type of iron bed, and the rest is moved along by rack and pinion. The T-rest may be replaced by a tool-holder, for dimension-turning of true cylinders. The shears have a flat top, and some builders make them solid across the top, with raised ways near the edges. The extra face-plate and tool-rest form part of this lathe also.

So simple is the wood-turning hand-lathe that it scarcely deserves further mention. Its large and varied capacities are due to the skill of the operator who manages it. But where a large number of duplicates are to be turned, a gauge-lathe will be employed. One man can attend to several machines, and all time for calibration and measurement is saved. The tool is held upon a carriage which receives its feed-motion parallel to the axis of the work. The position of the cutter-point is determined by a pattern or former on the lathe-shear. This former is fixed, and a pin or roller, moving over it, is compelled to vary the radii of the surface of revolution being turned. The tool-point is retracted or advanced as compelled by its connection with the pin at the pattern.

Fig. 509 shows a type of carriage to be run on a false shear on any lathe. The cutter is pivoted near the front end of its lever, and the knob on the rear passes over the corrugations of the pattern. The stock is kept from springing from the cut by the concentric disk, drilled with holes of varying diameter. The longitudinal feed may be given in any way, a very simple one being by a knife attached to the slide, which can be adjusted to take the stock at any inclination and generate any spiral or desired feeding speed. More usually these lathes are specially built, and have a screw-feed.

Fig. 510 shows how this may be applied in front of the shears, driven through an intermediate idle shaft with cone-pulleys from the driving-spindle. The feed is disengaged by clasp-nut at the end of a traverse, when the

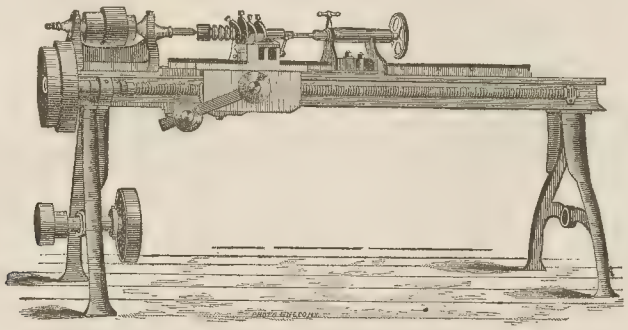


Fig. 510.

carriage strikes stops. The cut shows the use of several tools to distribute the strain of the cut and vary the finish. The pattern also in this lathe is central to the bed, so that no allowance has to be made for the differences in lever-arm of the guide and cutter. Where the pattern is at one side, the profile of its edge cannot be taken directly from the drawing of the finished work. A type of similar lathe, with devices to avoid stopping its motion, is shown by Fig. 511. The stock is guided centrally to the spur-center by the cone. The dead-center is brought up by

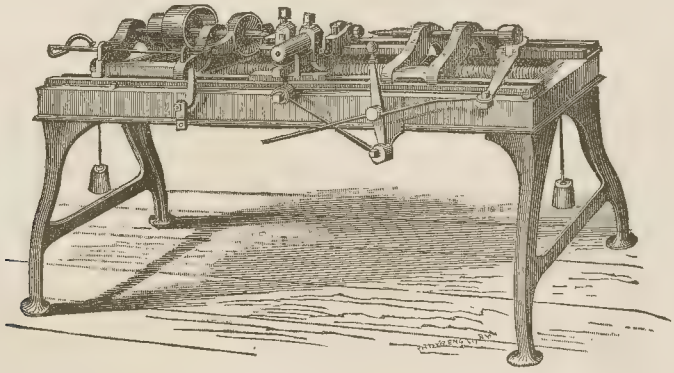


Fig. 511.

leverages and links, so as to save the stops and time required to get to it on long work. The feed-screw is between the shears. The larger and more elaborate gauge-lathes have a roughing-cut taken by a tool-point guided by a former, and finish the surface by the action of a knife which has the required profile.

Fig. 512 illustrates one of these. The carriage has a slide which fits the diagonal way planed upon the frame which holds the knife. The roughing-cut is made by the tool in the holder, guided by the former on the back shear. The knife is brought down behind the first cutter, and completes the work to a true profile. The knife, being set diagonally to the axis of the work, makes a progressive or dragging sort of cut, and cutting-off tools

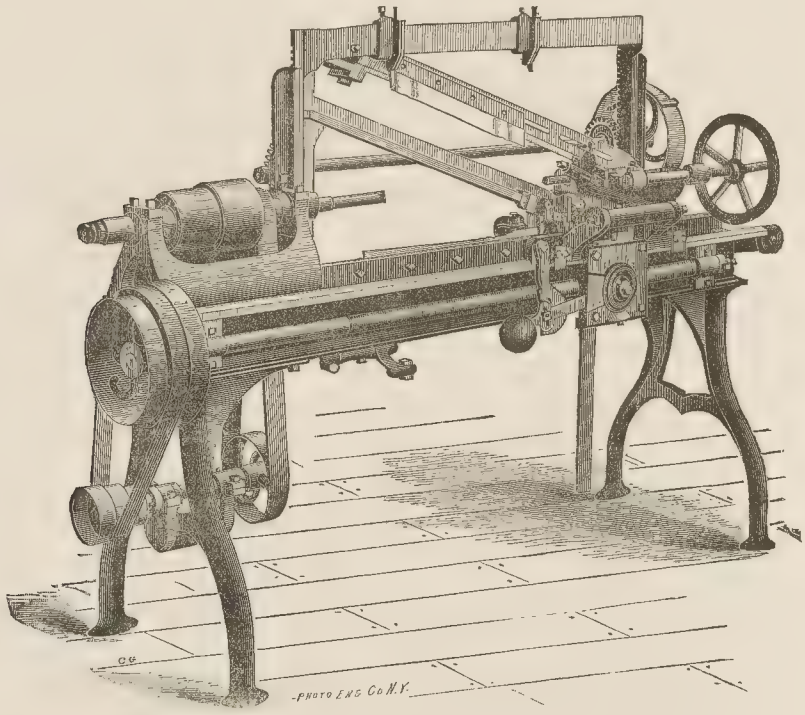


Fig. 512.

may sever the finished from the rough stock. The frame is equalized by racks, into which mesh pinions on the cross-shaft, which is counter-weighted. Stops release the feed, and a weight may draw the carriage back for a fresh piece. The design of Fig. 513 has the finishing-knife formed into a spiral, and brought down to the work by hand. The knife revolves around an axis, and the previous diagonal of a rectangle must become a helix. The

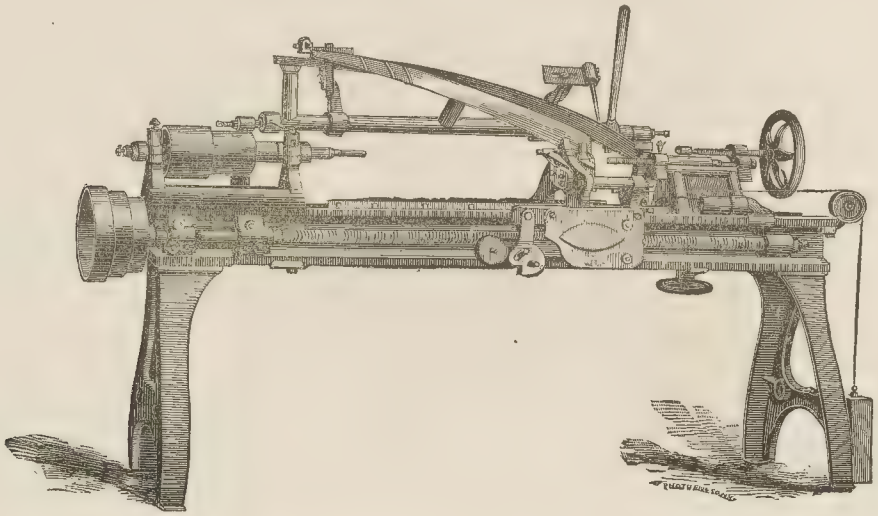


Fig. 513.

same progressive cut is insured, and a smooth, polished, or dead surface may be left, as desired by the operator. The centers of the knife-frame may be taken up for wear. In its other features it resembles the previous design. A ring center-rest, sized to the dimension of the largest part, is attached to the slide of long lathes for slender work. It is claimed for this second form that it is easier to handle in the case of breakage of half-finished work.

The gauge-lathe cannot be conveniently made to produce any but external surfaces of revolution. It is also unnecessarily heavy for a great deal of small work. The Waymouth lathe (Fig. 514) is designed to meet this

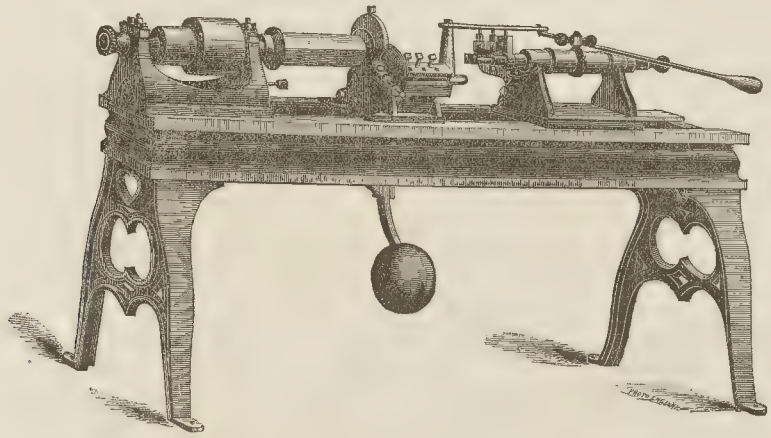


Fig. 514.

necessity, and will bore as well as turn. It is possible with such a lathe to turn 10,000 druggist's boxes in ten hours. The general principle is the successive presentation of properly shaped and located tools by the hand of the operator, or by his knee. These tools are fed up to stops laterally and longitudinally, and must therefore turn out work to standard size at every presentation. The stock is seized by an internal conical screw-chuck, which centers and rotates it. A tapering ring-tool on the carriage sizes and guides the stock, while the tool in the tail-

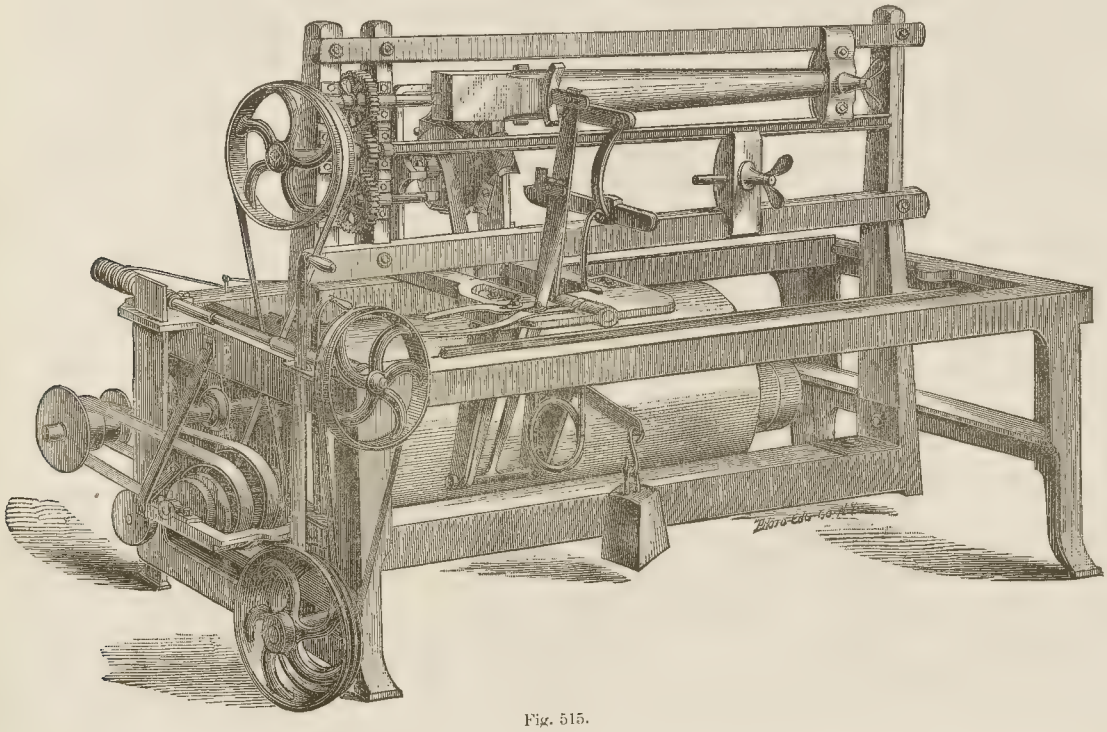


Fig. 515.

stock, fed forward by the hand-lever, acts on the end to do what may be there required. Behind the ring-tool is a holder for different special shaping tools. This holder swings toward the work around a hinge-joint near the foot of the carriage. The presentation of the holder is made by pressure of the knee upon the pad on the end of the lever. This lever turns a wrist-plate by a pin. A second wrist-pin throws forward the series of tools on the finishing-rest by a connecting-rod. This latter pin is so arranged that the tools in the holder can only be moved forward the required distance. Any further pressure retracts the tools, because the pin has passed its center. The circumference of the wrist-plate is toothed, and further pressure on the pad feeds up a cutting-off tool by a rack from below. The carriage and tail-stock are gibbed to the inside of the shears. This type of lathe is an exceedingly ingenious device for multiplying the capacities of the machine many fold. While hand-labor is retained to work the tools, yet the element of inaccuracy is eliminated, and all necessity for calibration disappears. Many classes of work could not be so well done by any other machine.

The term lathe might be restricted to those machines which produce volumes of revolution, as in the preceding examples. The name is often extended to cover a class of tools for the reduplication of irregular forms, such as gun-stocks, wheel-spokes, and handles for axes and picks. These are often called Blanchard lathes from the original patentee, whose patent dates from 1819. In their general features they consist of rotating cutters secured to a head. Some of them are roughing-cutters, and others for finishing. The former lead the latter, so that the work may be finished at one traverse of the cutter-head along the stock. The pattern and blank are borne in a frame pivoted below. This frame is controlled in its horizontal motion by an arm on the cutter-carriage bearing a friction-roller which rests against the pattern or former. The stock to be turned is held on centers parallel to the pattern, and the cutters are permitted to remove chips only so far inward as the pattern will permit. The pattern and the blank are slowly revolved, and the former is exactly reproduced. The older type of the lathe, which has advantages for certain duties, is shown by Fig. 515. The frame holding the pattern and blank is stationary endwise, and the carriage carrying the revolving cutters traverses along it. The long drum below drives the cutter-head, wherever it may be. The pattern is above the blank, and has to be larger, of course, than the finished article, which is centered nearer to the center of motion of the forming-lever. The blank and pattern are revolved at a speed of 60 or 80 turns per minute by the train of gears driven by belt from the cone-pulleys. The traverse of the carriage is effected by flexible connection, actuated by belt or by a worm device. The pressure upon the pattern and from the back-rest may be controlled by spring or by weight, or by both. The retreat of the frame at enlargements of the patterns is insured by the pressure on the front side. The feed is disengaged at the end of the traverse by the dogs on the carriage. In place of the wing-nut for adjusting the lower dead-center, a cam-lever may be used. The drum is sometimes mounted separate from the frame of the tool with advantage. Two hand-levers control the motion of the blank and the feed of the carriage and cutter-head.

Another form of the Blanchard lathe is shown by Fig. 516. The blank and pattern are centered upon uprights bolted solidly on a carriage, and the latter receives the traverse motion in front of the stationary cutter-frame. The

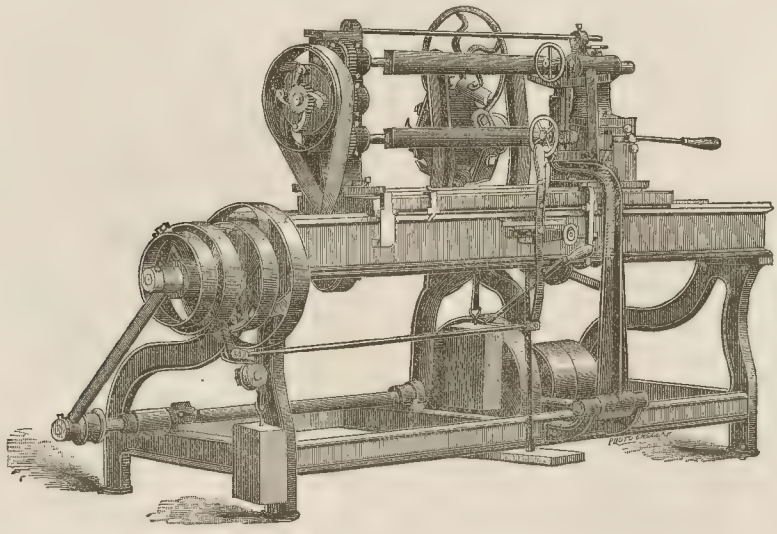


Fig. 516.

use of a long drum is thereby avoided. The yielding for variations of profile is given by the cutter-frame and not by that which holds the work. The cutter-frame is kept to its work by a weight, and a spring-back rest is provided

to keep the blank from flexure. Dogs on the carriage disengage the feed at the ends of the traverse. The wheel which turns the blank and pattern is connected to the gears by ratchet and pawls. The inconvenience of revolving the blank when running backward is thus avoided.

Fig. 517 shows a lathe with drum overhead and traveling cutter-carriage. The latter moves on rollers, and is made heavy to resist the jar of the cutter-head, which revolves at 8,000 feet per minute at the circumference.

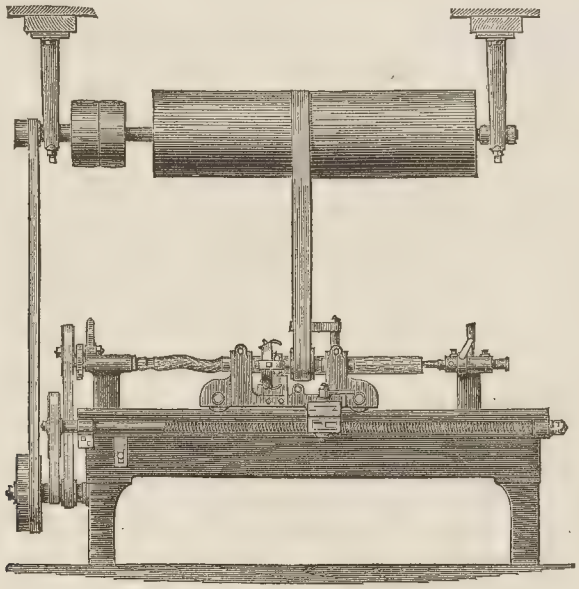


Fig. 517.

The feed is by the bed-screw, and is made variable by change-pulleys at the head. The pattern lies in the same plane as the blank, of which it is an exact duplicate. The same feature of exact duplication of form is obtained by the design of Fig. 518. The cutter-frame is fixed, and the holders turn on an axis as in the preceding design. The rotation of the blanks is given from the drum at the back, and the carrier-frame traverses horizontally. The

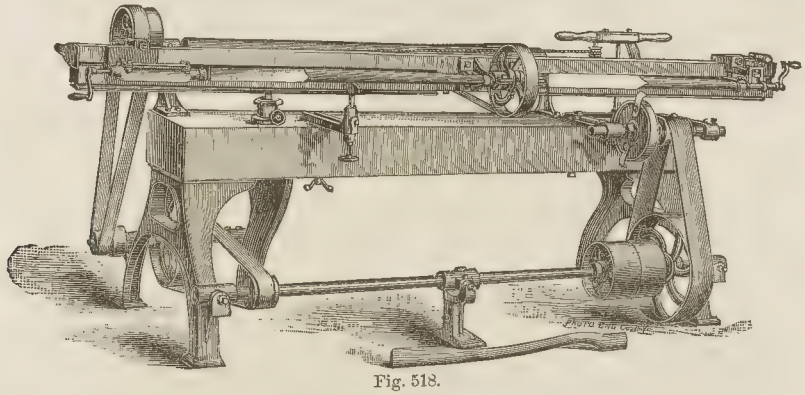


Fig. 518.

tilting carrier-frame is adjustable vertically for different diameters of work. The stops are automatic, as are the feed-motions. Saws may be used instead of cutter-heads if better adapted for the wood or the shape. These tools have been so long and so well known that extended reference to their capabilities would be superfluous. The improvements of latter years have been in details of construction to keep pace with the march of mechanical progress.

Akin to the action of lathes (although inverted) is the action of rod, pin, or dowel machines, such as Fig. 519 *a*. The stock is fed in by hand, and is shaped by the revolving knives. The slope of the knives draws the work inward toward the cutter.

Fig. 519 *b* shows a chuck or holder for steadying the work, and preventing it from turning in the hands of the operator. The machine is exceedingly simple, and is of very great service in many shops. Power-feed machines upon standards are also made.

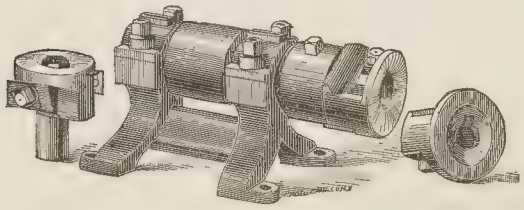


Fig. 519 *a*.

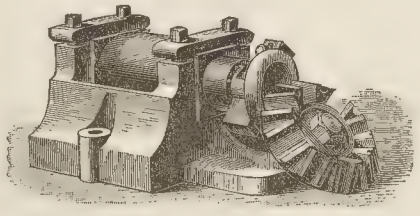


Fig. 519 *b*.

Akin also to the lathes in their action on the lumber are the spiral veneer-cutting machines of which Fig. 520 is a type. The log revolves slowly in front of a stationary knife, which advances by the thickness of the sheet at each revolution. All loss from dust and saw-kerf is thus avoided.

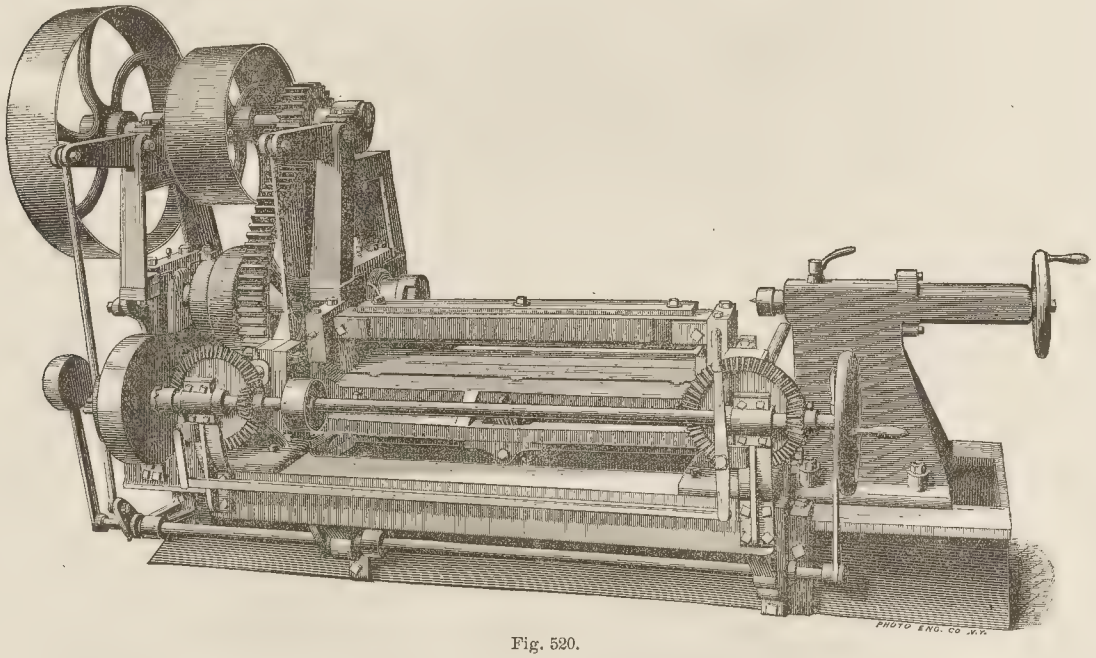


Fig. 520.

§ 52.

TENONING-MACHINES—GAINING-MACHINES.

The joint by tenon and mortise is of primary importance in wooden constructions. Machines for making the parts of the joint will be of wide application in car, carriage, pattern, and bridge shops. The tenon is made upon the end of the piece. A rotating cutter will, therefore, sever the fibers and split them off for the required distance. The severing of the fibers will be done either by sections of saw-plate, or by spurs on the chisel edges of the paring-cutters. The cutters are often arranged spirally, so as to produce a dragging cut, and more in the direction of the fibers. The work is fed to the cutters in the smaller and medium sizes; in the larger designs the cutters may move toward the lumber. This latter arrangement is specially applicable to the machines for double tenons.

In the series of designs of which Fig. 521 is a type, the framing is mostly of wood, with some parts of iron. The lower head is stationary. The height of the lower shoulder is varied by raising or lowering the carriage-ways by the inclined planes operated by the hand-crank. The thickness of the tenon is varied by the rise and fall of the upper cross-frame, which is pivoted at the upright at the rear. The tilt of this frame is controlled by the screw-

and hand-crank in front. The bearings of the upper cutter are adjustable longitudinally to permit the upper shoulder to be offset from the line of the lower, if desired. The two cutter-heads revolve in opposite directions so as not to tend to twist the stock. This latter is held and steadied on the carriage by the foot upon the adjustable hand-lever. But one belt is used. It passes from the driving-pulley below up over the upper head, thence down

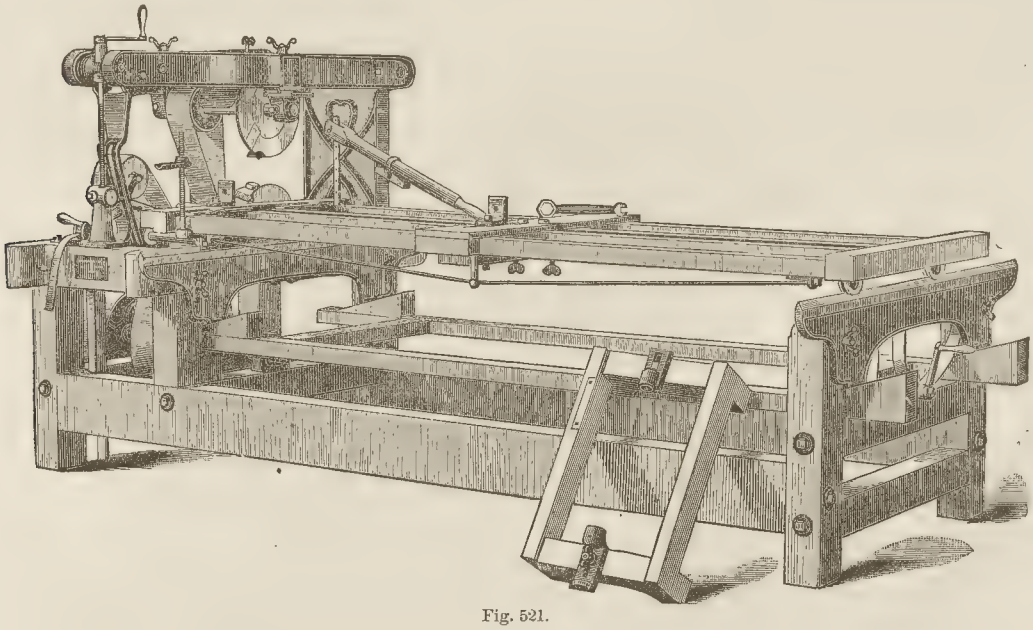


Fig. 521.

under the lower head and upward over a tightener and guide-pulley to complete the circuit to the driving-pulley below again. By this means the cutter-pulleys have the belt around half their circumference, and variation in the thickness of tenon is compensated for. In the form shown the tightener is on an upright, and a flexible thong is clamped to maintain the due tension. Fig. 522 shows a wood-frame machine, with the addition of cope-heads for

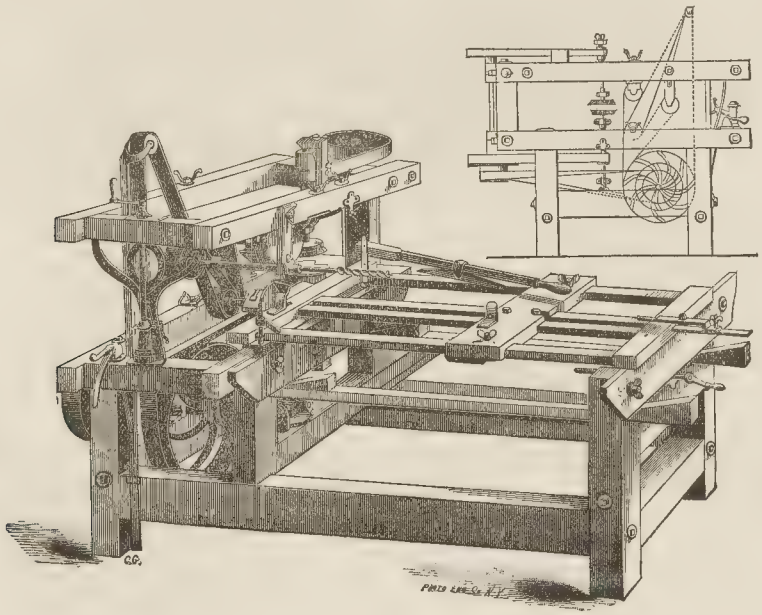


Fig. 522.

profiling the shoulders of the tenon. They are on vertical axes, as shown in the skeleton front view, driven from a counter-shaft at the end. The tightener-pulley stands higher, strained in the same way, and an adjustable boring attachment may be applied, if desired. The cope counter-shaft is driven by a quarter-twist belt from the lower shaft. The design of Fig. 523 illustrates a type of framing partly of iron and partly of wood. The table guiding the carriage has no adjustment, since all required motions are given to the cutter-heads. The frame carrying the lower head is raised and lowered, for the variation in lower shoulder, by a screw turned by the larger hand-wheel. The

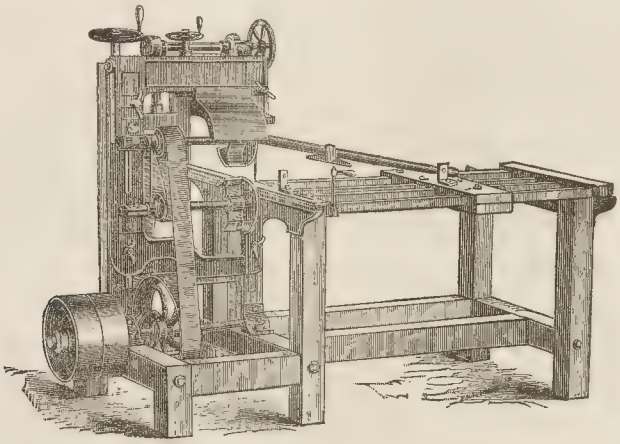


Fig. 523.

frame of the upper cutter is faced to the frame of the lower, and adjusts to the latter by the smaller hand-wheel. By this method both cutter-heads may be moved up or down without changing their relative positions to each other. The shoulders may be varied, therefore, without change in the tenon, or the tenon may be changed without altering

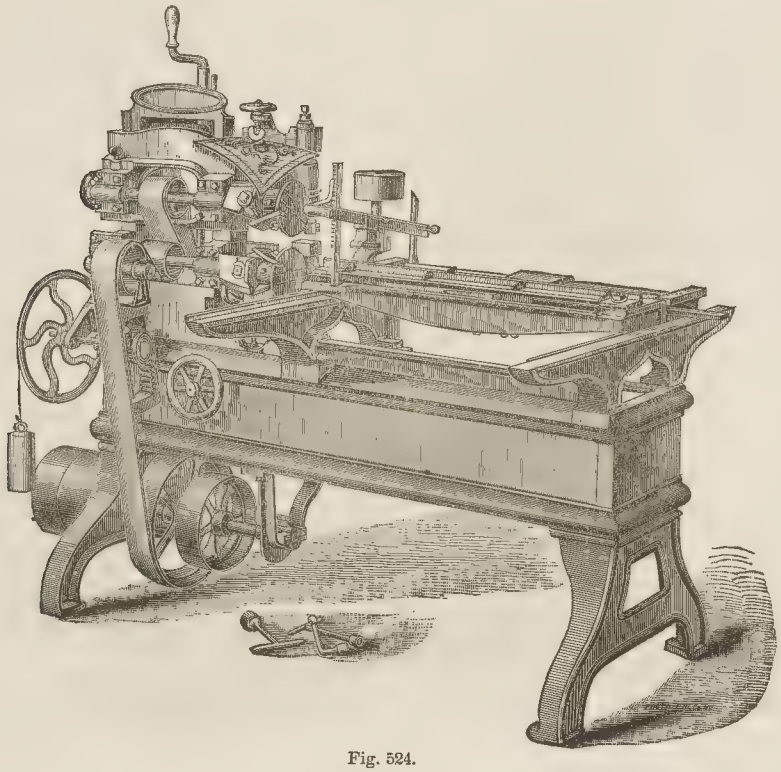


Fig. 524.

the lower shoulder. The upper boxes may be moved to offset the shoulders. The tightener is adjusted by a ratchet and pawl shaft turned by the hand-wheel. The front string piece on the table is of iron, guiding the end next the cutters and permitting increased depth of shoulder to be cut on the lumber.

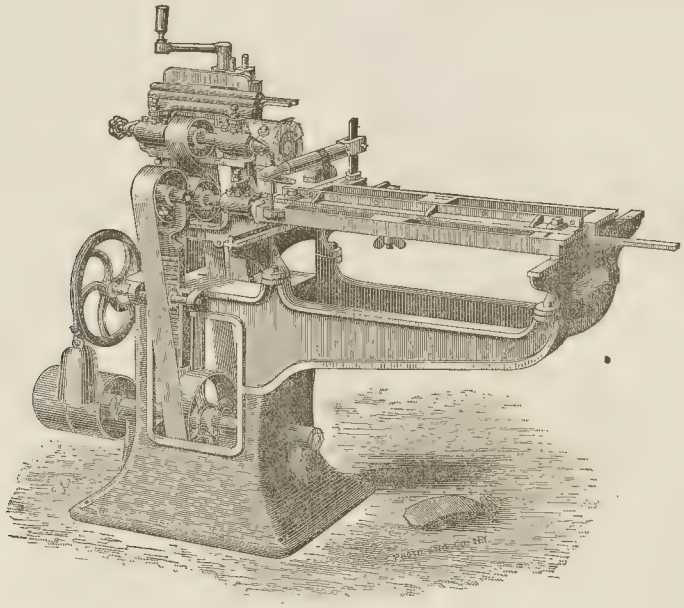


Fig. 525.

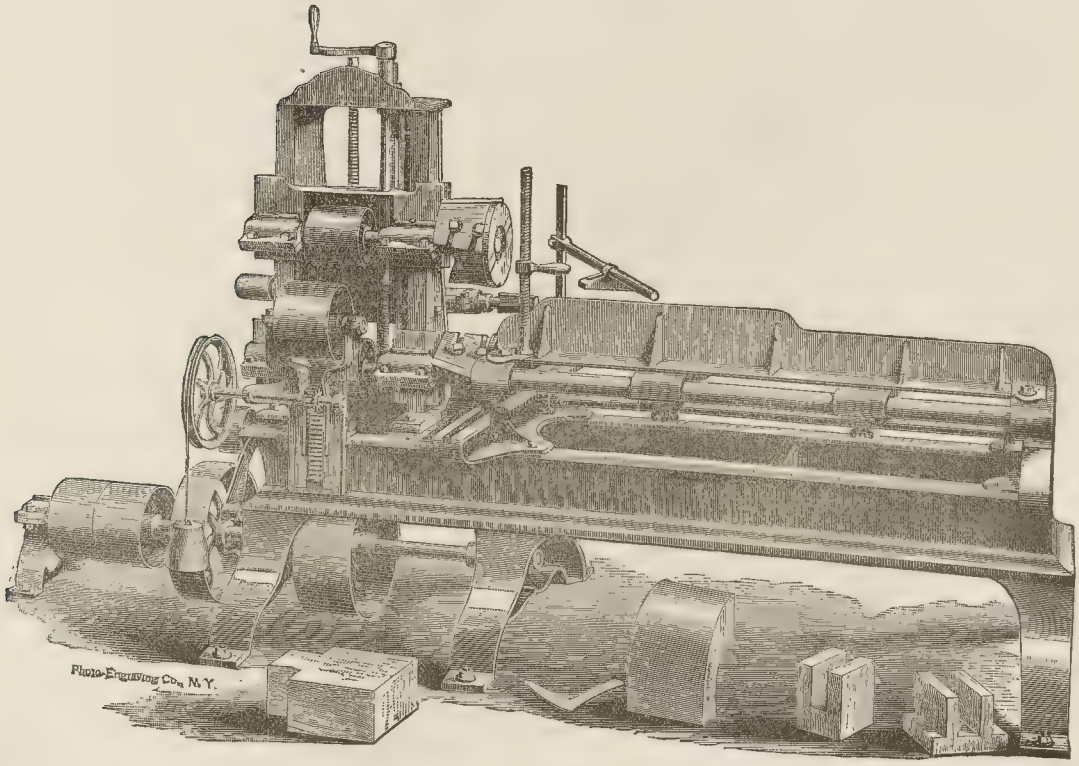


Fig. 526.

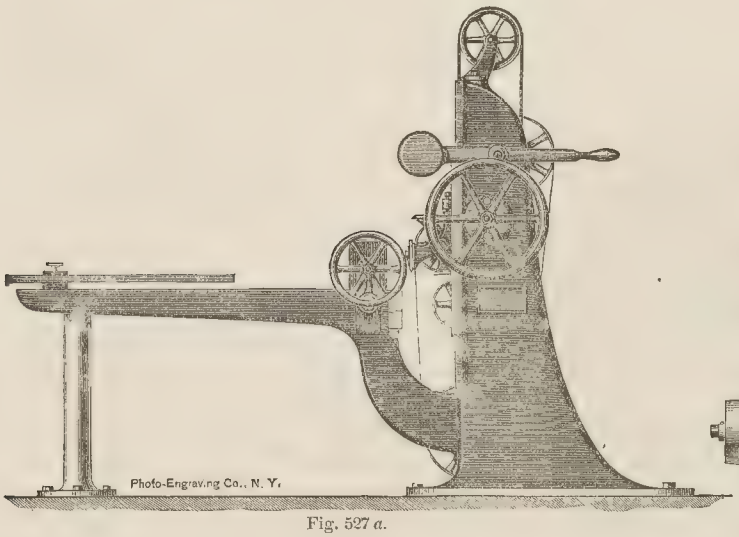


Fig. 527 *a*.

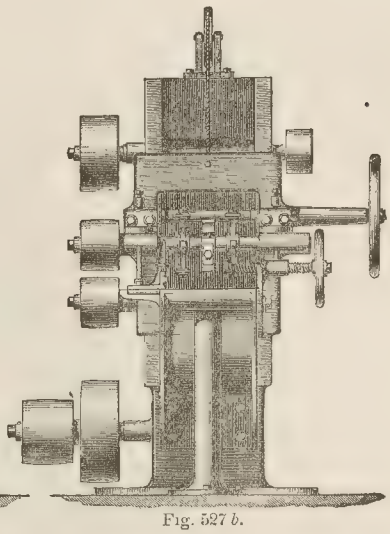


Fig. 527 *b*.

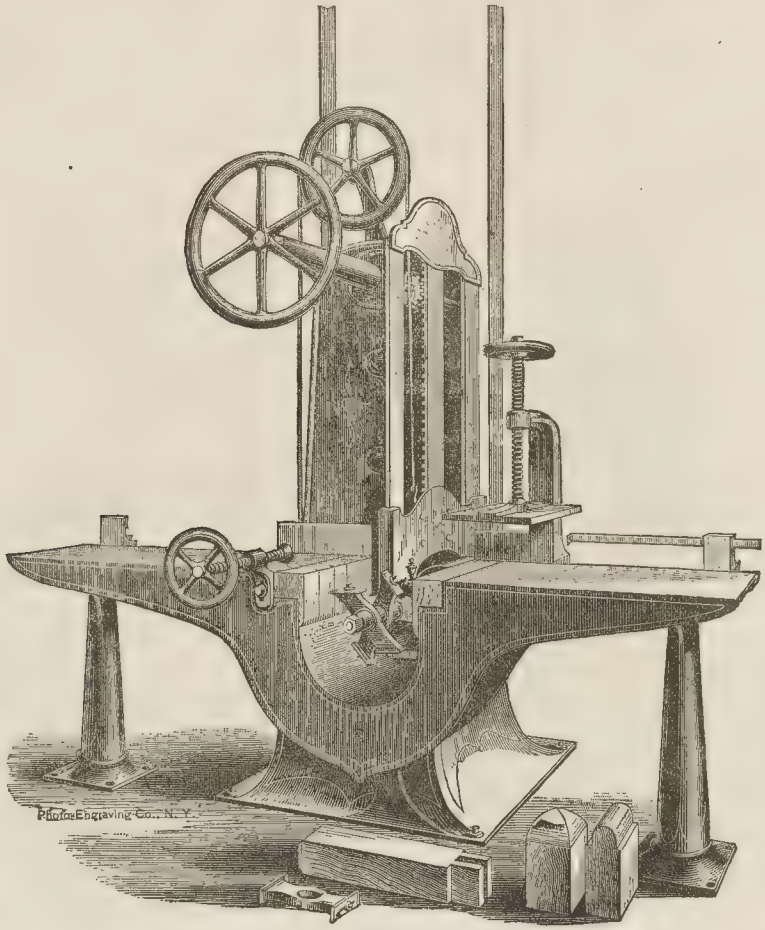


Fig. 528.

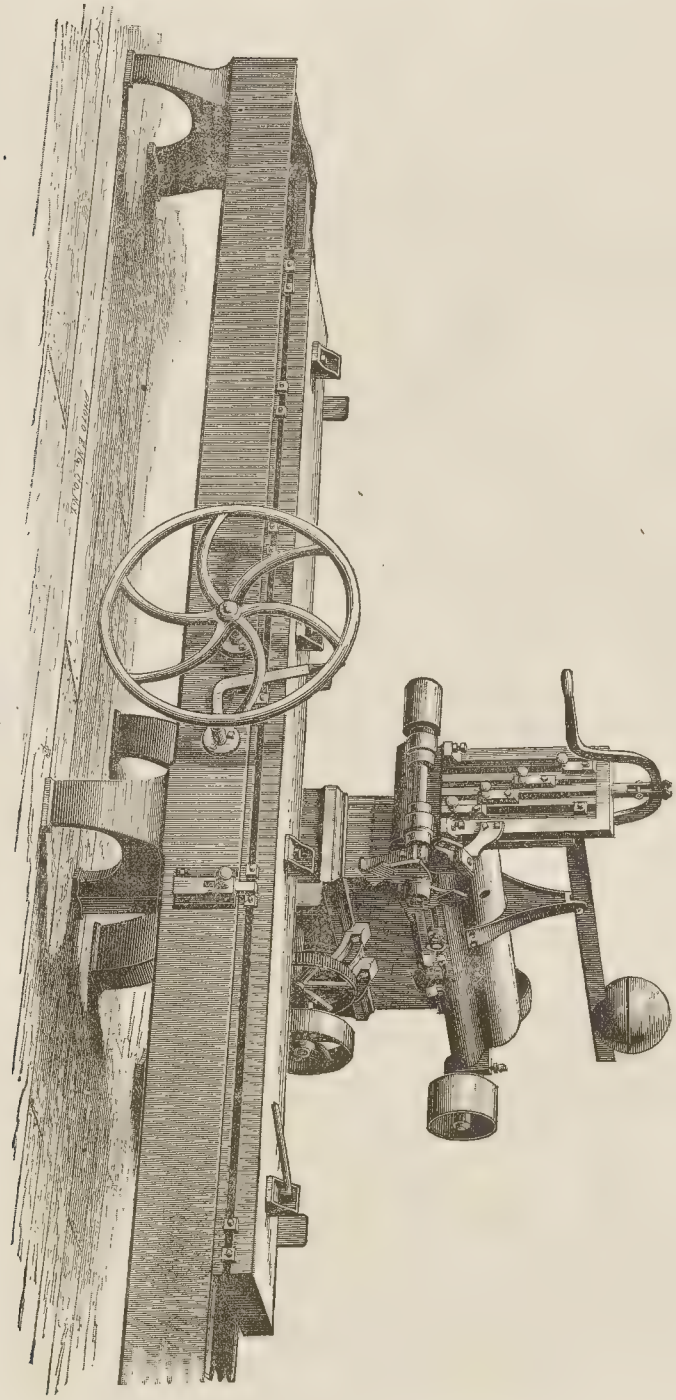


Fig. 629.

Fig. 524 shows the average size of iron-frame machine, with adjustment of the heads upon slides. The binder-pulley is counter-weighted in the simple manner which is usual in the newer tools. The holder of the roller has a rack cut on it. On the axis of a pinion which meshes into it is a larger grooved wheel, round whose circumference is wound a wire rope sustaining a weight. By the gain of leverage a light weight is competent to strain the belt.

Fig. 525 shows a new standard machine for cabinet- and spoke-work. While the cutters on the sizes hitherto have been known as 8-inch heads, those on this machine are but 5 inches, so that higher speed may produce smooth work. The especial feature of this design is the use of gibs under the slides of the table, so that by no possible overweighting or lack of balance can the table be thrown into the cutter-heads. The adjusting-screws for the heads are conveniently geared so that they may be moved together or separately. The upper spindle-boxes move in dovetail slides by the hand-wheel at the tail for offsetting the shoulders. The machine of Fig. 526 is the size adapted for car and other heavy work. The two ends of the long table are compelled to move together without binding on the ways by pinions on a shaft, which mesh into racks under the ways. These also prevent the table

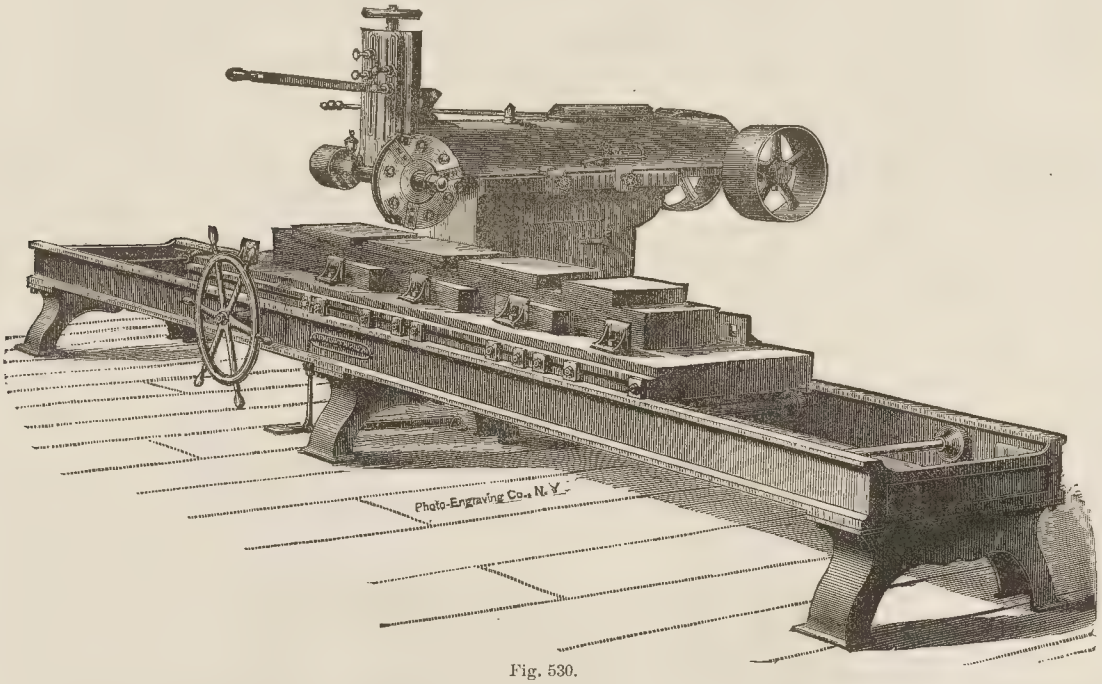


Fig. 530.

from tilting. On the rear of the standard is a third removable head acting like a rotary mortiser to make double tenons, as in the sample at the foot of the machine. This small head is driven by a separate belt outside of the head. The method of adjusting the heads is very obvious, as also the shape of the cutters for a dragging cut. It is more usual, however, where multiple tenons are to be cut to change the system of design, and to have the cutters on an axis at right angles to the axis of the timber. Moreover, as the timber usually is very large and heavy, when multiple tenons are desirable, the cutters are made to traverse across the work which is held stationary.

Figs. 527 *a* and *b* show one form of this type of machine. The work is presented from the front of the machine The cutter-axis is borne on a counter-weighted slide which is moved up and down by the large hand-wheel. The belt passes from the shaft at the base over the cutter-pulley, and thence under and in front of a guide-pulley on the slide. From underneath this it passes over the upper pulley and so back to the driver below. The driving is thereby with constant tension on the belt.

Fig. 528 shows a type of multiple tenoner, by which both ends of a long timber may be tenoned from one face without turning it round. The action is the same as in the preceding designs. The timber is clamped upon the table and finished at one end by lifting the slide, and is then slid over the gap and is tenoned at the other end on the descent of the cutters. End-molding or shaping-cutters may replace the tenoning-heads for certain duties. The clamping devices may be doubled on each side of the gap, with the counter-shaft on the floor at the side. In Fig. 528 the counter-shaft is overhead, and the clamps are single. To prevent splitting and fraying at the lower edge the lip of the gap of the latter is faced with wood, to which the cutters come very close. Gauges are easily

attached for standard lengths upon the tables. Such machines as these will operate on heavy work as fast as it can be presented to them. They possess marked advantages over the machines with similar functions in which the axis of the cutter is vertical and receives a horizontal traverse. This latter arrangement is not in use in this country. It is, of course, a simple operation to make any tenoning-machine cut the shoulders oblique to the long axis of the timber. It is only necessary to make the obvious change in the plane of the table or fence. Any extra-long work can also be done by the use of double sets of cutters.

Closely akin to the tenoners of the previous class are the tools which are called gaining-machines. A gain is a groove cut across the grain of a timber, usually at right angles to its length. The gaining-cutter will, therefore, require spurs or saw-segments at both sides, instead of upon one only. The gain and the tenon may be of the same depth and length in work of given dimensions. But the gain is not at the ends, nor usually near them, and hence a special class of tool is made to produce them. The general type of machine is shown by Figs. 529 and 530. The cutter-axis is driven from the pulley at the rear. Both are borne upon the long gibbed slide, which moves forward across the table and causes the cutters to plow the gain. The shaft at the rear receives its motion from a counter overhead, which stands over the middle point of the traverse of the pulley. The motion backward and forward is effected by a train of gear, which drives a pinion meshing into a rack on the under side of the slide. Adjustable stops make the reciprocation and the arrest of motion when the slide is back to be entirely automatic, but a hand-lever may operate these devices at any time. Power for the traversing is obtained by belt from the counter to the pulley at the side of the base. Both forward and back traverse may be at the same speed, and the cutter may act on both motions as in the vertical tenoner. The cutter-axis is borne on a vertical slide, by which the depth of the gains may be varied. Stops may be fastened to the rear plate, and these may serve to arrest the downward motion of the front slide at any depth or at any series of depths. Gains of different depths may be sunk in the work by using different stops in the four slots of the face. Any of the stops may be made inoperative at will by pulling out a pin in its center. No readjustment is required when the stop is to be used again. The pushing in of the pin of any one stop causes it to serve. The weight of the slide is borne either by a counter-weight on the hand-lever, or by a series of springs in the back-plate. The stuff to be gained rests on a carriage, to which it is secured by wedging it against knee-blocks. The table moves on friction-rollers, and is guided by ways. It is moved by rack and pinion from the large hand-wheel in front. In front of the carriage or table is a T-slot, by which a series of dogs or chocks may be secured. In the path of their motion is a projecting pin, which may be pulled out of the way by treadle or handle, but which returns to its place by a spring. These stops may be spaced so as to produce standard spaces or widths of gain in series of duplicates, without loss of time for measurement. Their function is identical with that of the stops on the vertical slide, and add immensely to the capacity of the machines.

In the design of Figs. 531 *a* and *b*, the long slide has a quick-return. The vertical lever which projects up through a slot in the slide is pivoted upon the center just under the ways. The arm which hangs downward from

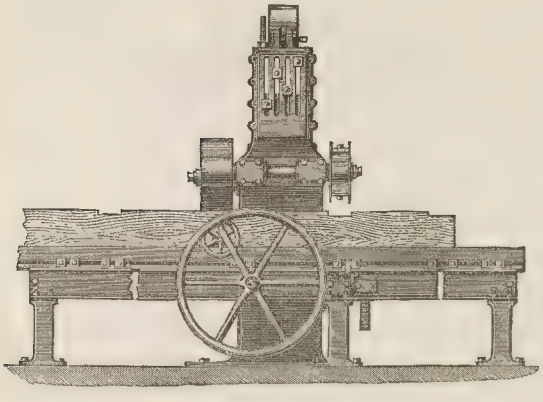


Fig. 531 *a*.

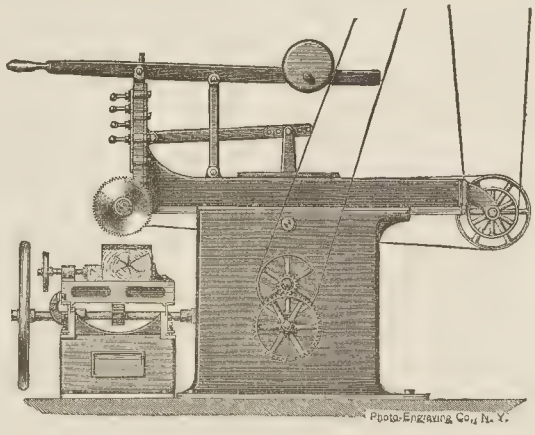


Fig. 531 *b*.

this center carries a slot into which is fitted a crank upon the axis of the larger lower gear. It will be seen that when the crank is down it acts to move the slide forward slowly with long leverage. When the crank is up it acts nearer to the center of motion, and brings the slide back rapidly. The horizontal link has several holes to enable the slide to overhang more or less. In this design a full saw is used on each side of the paring-cutters. Segments of saw-plate are more usual.

Fig. 532 shows the ordinary form of groover-head as used for sash- and door-work. The cutters have spurs, and are held in place by taper compression-bolts.

Fig. 533 shows a type of expanding-head for gaining-machines. The cutters are compressed by bolts in slots,

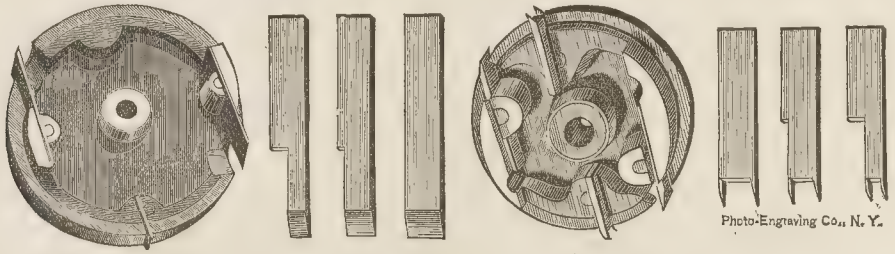


Fig. 532.

and, by changing the chisels, the widths of the gains may be varied. Different types of expanding-heads are used for various purposes, such as dado work, for example, differing with the method of mounting (Figs. 534 and 535).

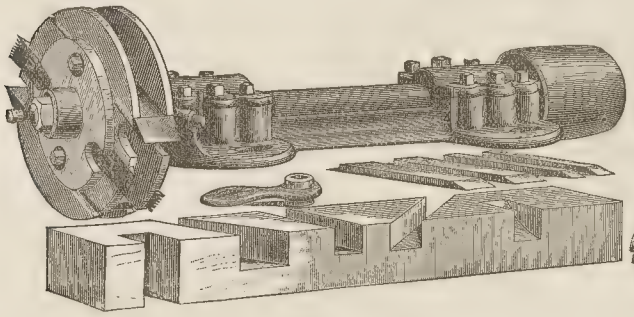


Fig. 533.

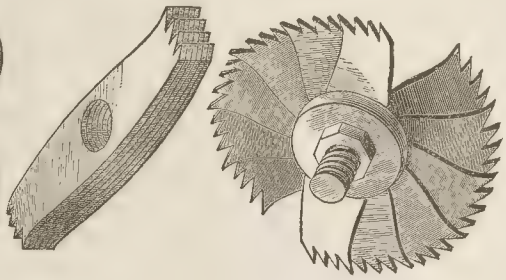


Fig. 534.

A reference to tenoning-machines would be incomplete if it did not embrace the machines for special tenoning, such as are required in blinds and wheel-spokes. The slat of the blind, having been shaped upon a sticker, is held in a chuck, and revolved while it is presented to the cutter. The tenon is made round by the rotation, and the end does not split or fray.

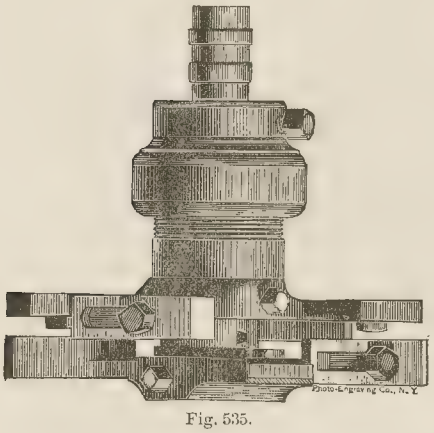


Fig. 535.

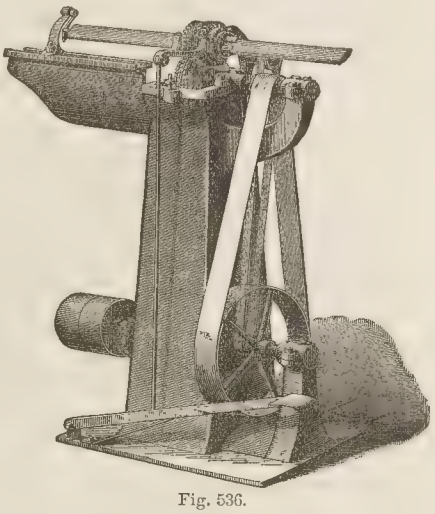


Fig. 536.

Fig. 536 shows a form of machine embodying the features of the Ellis & Bickford patents, which divides the slat and cuts two tenons in the middle. In the Ellis machine the tenons are cut at each end of the slat by two cutters.

Fig. 537 illustrates an oval tenoning-machine as applied to wheel-work. The wheel is chucked on its hub, and a small circular saw cuts all spokes to the same length. The spoke which is operated on is held by geared centering-clamps, which bring the center of a spoke of any size to the center of the revolving disks. The upper part of the machine which carries the cutter-heads has two disks, which are revolved by a series of cut gearing, governed by a lever for the foot, which acts upon friction-pulleys and is under the control of the operator. The

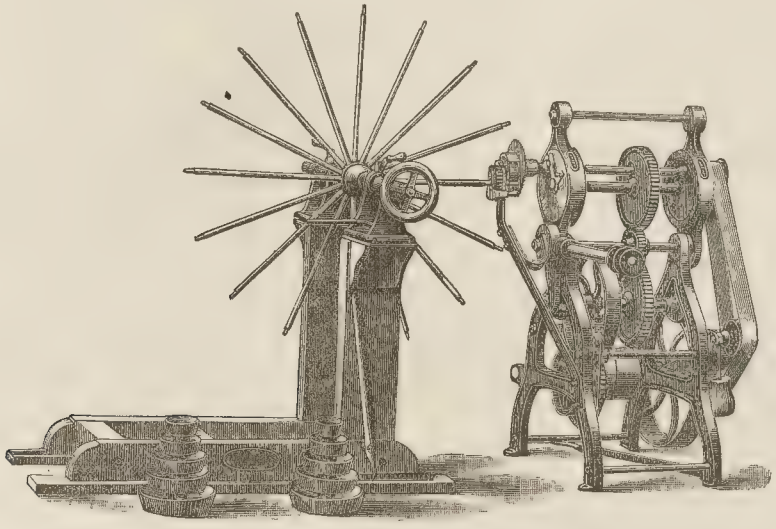


Fig. 537.

arbor on which the cutter-head and saw are secured passes through the revolving disks near their peripheries, the boxes in which it runs being secured to the disks, but they are adjustable by means of cams for the different tenons. The upper part of the machine in which the disks revolve has a vibrating motion given to it by the weighted hand-lever. By depressing this lever the cutter-head is brought forward and cuts the oval, which may be varied in size to suit the work required. The oval tenon reduces the danger of splitting the felloes, and may render wedging unnecessary. Wheel-making may also use machines for truing spoke-tenons, for bevel-facing, shaping and throating the hub-ends of spokes, or for making the simple round tenons used on ordinary spokes. Most of these, however, become special machines, applicable for one industry only.

§ 53.

MORTISING-MACHINES—ROUTING-MACHINES.

The mortise receives the projecting tenon. The cutter must produce a cavity in the solid part of the timber, and must act first to cut the fibers, and then to pare away the chips. Mortising-machines are of two general classes. The first includes those which act by rotating cutters, which cut both upon sides and end. The second class includes those which act by a reciprocating chisel. This latter class has several varieties. The principle of the rotary mortisers is found in the panel-sinkers and bracket-molding or carving-machines.

In a machine for small work, such as the chair and blind industries, the rotating arbor is pivoted at the rear, and receives a vibratory motion from a slower moving wrist-plate. This motion may be graduated at will and determines the length of the mortise. The slight curvature at the bottom of the slot is no objection.

Figs. 538 and 539 show two designs for the largest class of work, the older design having a wood frame, while the more recent pattern is of iron. The cutter has horizontal and vertical traverse by levers controlled by stops, and the length of the mortises is governed by stops on the feeding-table, as in the gaining-machines. The cutter-slide is counter-weighted to relieve the strain in widening mortises, and power-feed may be engaged to save time in setting the work. The new machine has capacity for mortises 12 inches deep and 16 inches wide and of any length desired. The high speed and freedom from jar adapt these rotary machines for the heaviest work in hardest or most unfavorable lumber. There seems good reason for the preference felt for them by many engineers.

The reciprocating mortisers belong to four classes. In the first class the chisel is driven from a simple wrist-plate by connecting-links, and the work is fed up to the chisel by the foot of the operator, which depresses a treadle. This type is adapted for cabinet and other work upon light material which is easily lifted. Types

of these machines are shown by Figs. 540, 541, 542, and 543. Figs. 540 and 542 show a boring attachment, which is very usual when hard woods are to be handled. In softer woods the chisel may penetrate without previous boring of the holes. The stroke of the chisel being unvarying, the depth and severity of its blow are gauged

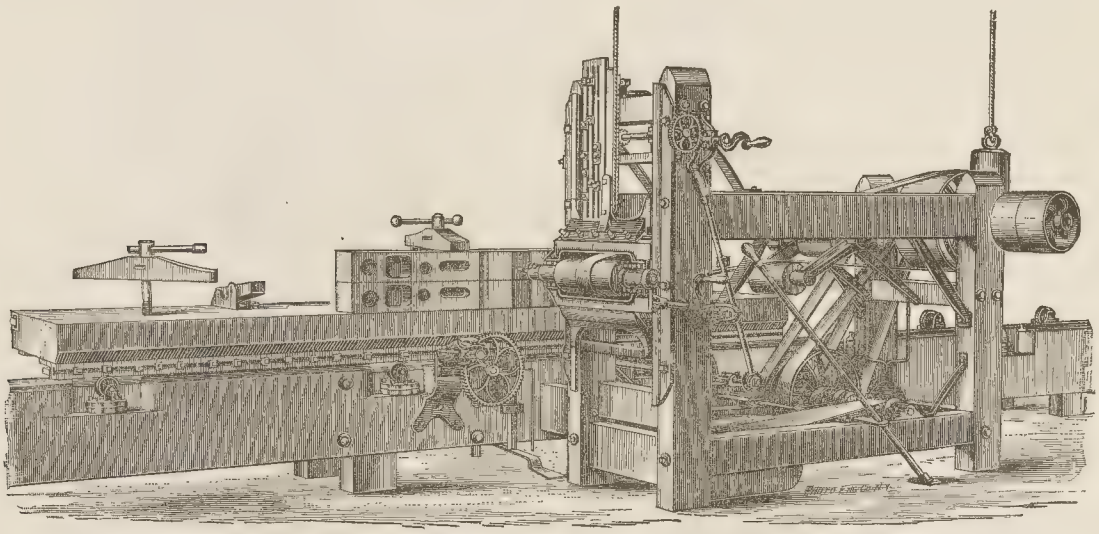


Fig. 538.

by the height of the treadle, and this may be made progressive. The work may be clamped to the table and fed along sidewise by rack and pinion, or it may be held in the hands only. The tables are made adjustable for various thicknesses by screws geared to crank-arbors, or by compounding the table vertically. The depth of the mortise is gauged by the fall of the treadle. In Figs. 541 and 542 the treadle is compound. In the former case the

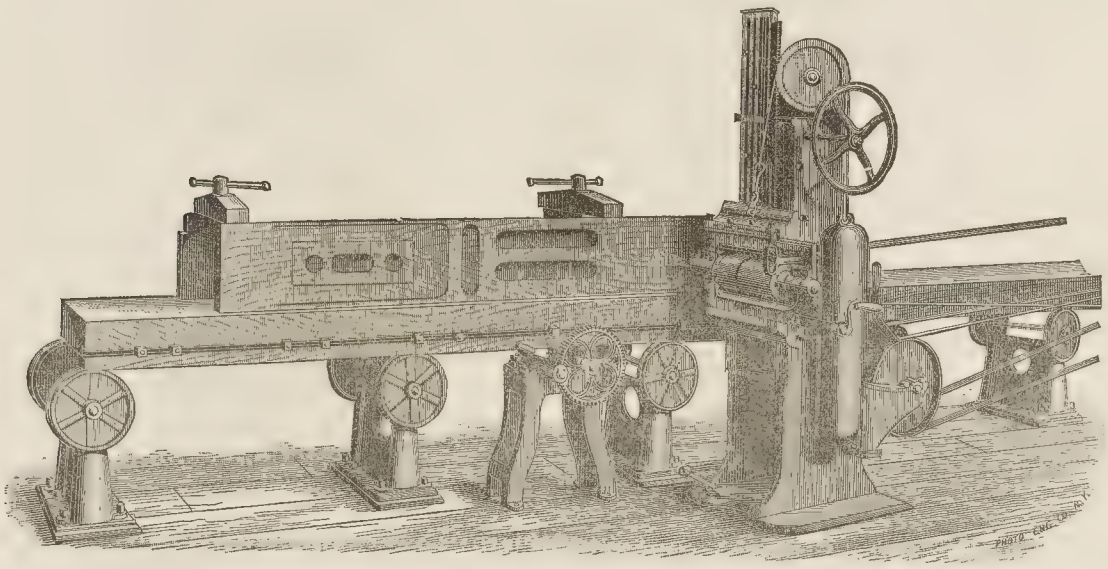


Fig. 539.

adjustment is by the set-screw. In the latter case it is by pawl and segment of a ratchet-wheel. In the designs of this class the treadle and the foot of the operator must receive and resist all the blows. In Figs. 540 and 543 the treadle resistance is so distributed by the truss construction that a large component of the deepest blows passes into the axis of the treadle and relieves the foot-pad. Ease to the operator is also secured by increasing

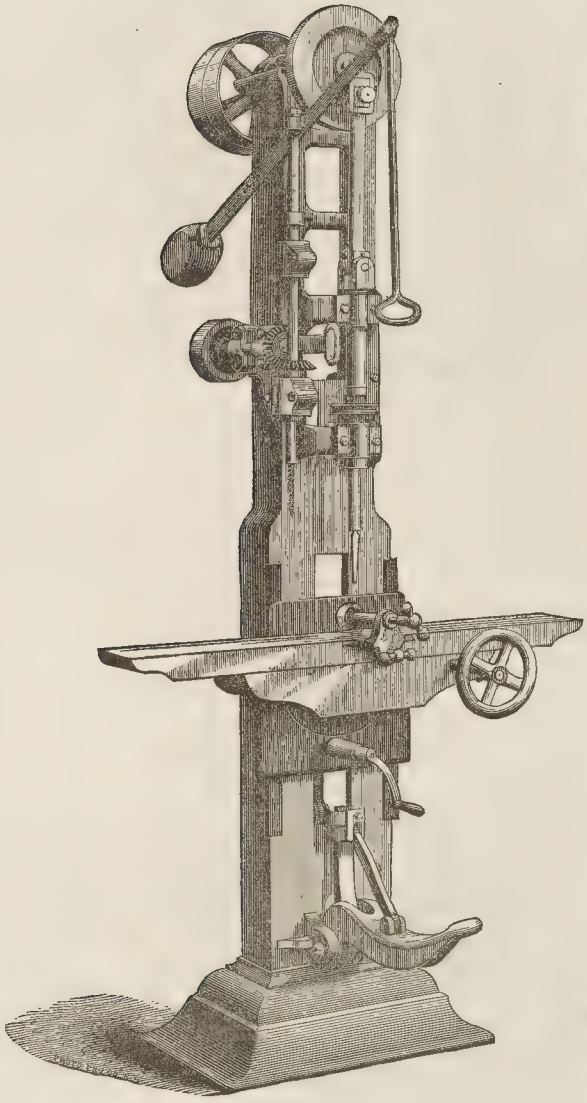


Fig. 540.

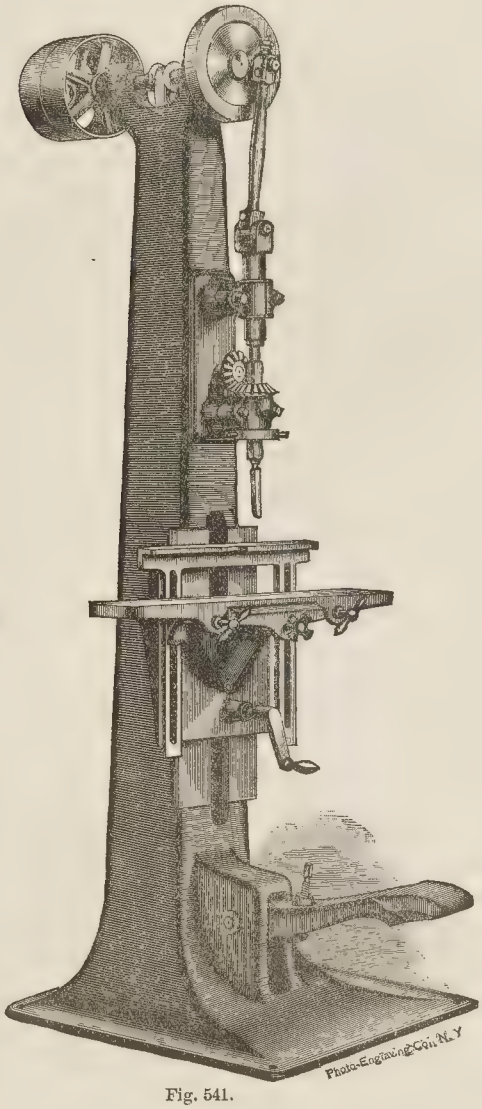


Fig. 541.

the inertia of the table and by running the chisel at very high speeds, which is possible when the reciprocating parts are light. The usual speeds are 500 blows per minute. The double wrist-plate design of Fig. 543 permits 800 blows per minute. It is necessary to reverse the chisel at intervals to secure the proper action of the spurs and straight ends to the mortise. This is done by several different devices. Figs. 540 and 543 use the round belt

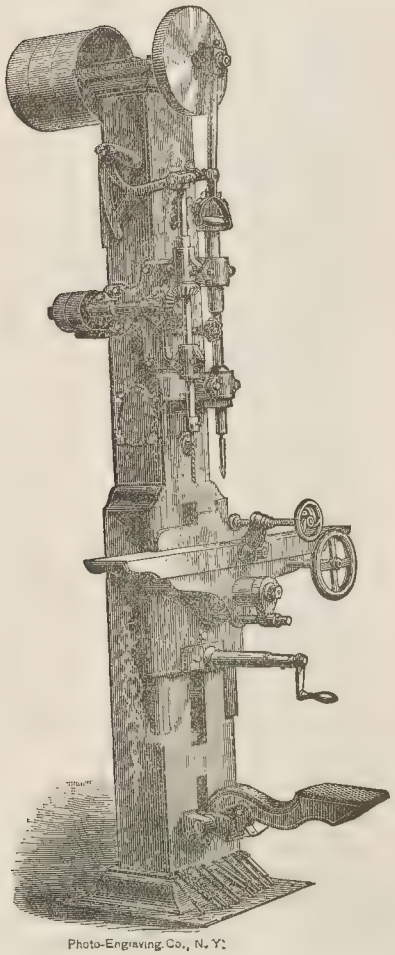


Photo-Engraving Co., N. Y.

Fig. 542.

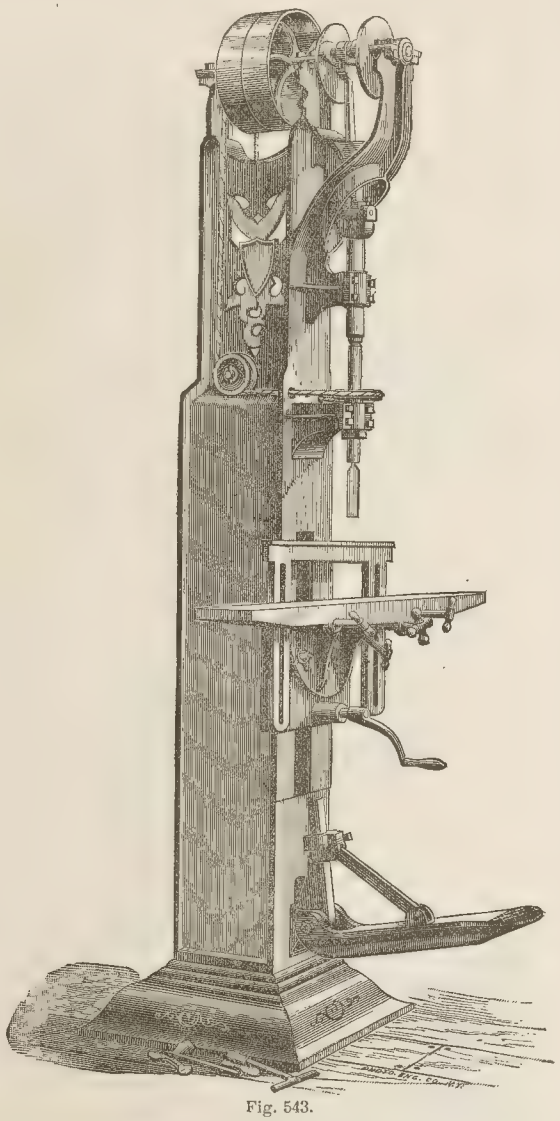


Fig. 543.

device, which slips around the pulley, except when the release of stops permit the bar to turn. In Fig. 541 flat belt is used and the pair of bevel-gear. In the tools of the builder of Fig. 542 there is a bevel-gear on the splined chisel-bar which is in gear with corresponding sector of a bevel-wheel. As the treadle rises it lifts a wedge-point, which strikes a corresponding wedge-point connected to the sector, and reverses the chisel, even if the machine is not running. This latter feature is often a convenience. The reversal of the chisel-bar necessitates an extra joint in the mechanism, which is to be avoided when possible. The rolling fulcrum for the boring-bar of Fig. 542 is a neat feature and avoids a slotted joint or an extra link.

Fig. 544 illustrates a unique machine with two reciprocating chisels. The machine shown is specially fitted for hub-work, and will stagger the mortises as well as do them straight. The table is lifted automatically by a cam-bearing on a roller. The cranks are connected by a drag-link, and the wrist-plate has a brake. The feed for raising the treadle is intermittent and easily disengaged.

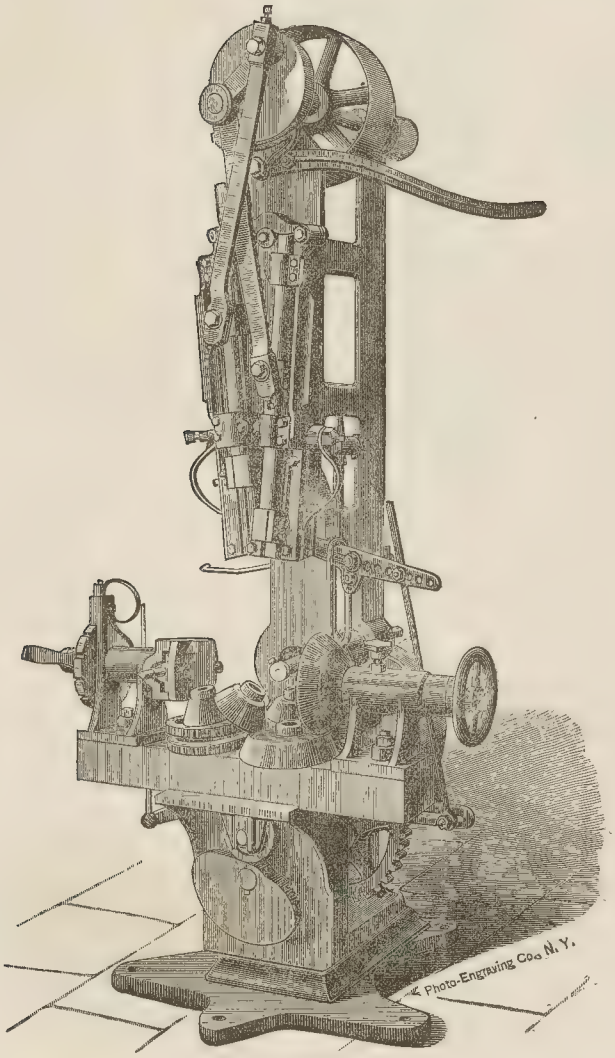


Fig. 544.

The second great class of mortisers includes those in which the table is fixed and the crank-shaft rises and falls to vary the depth of the blow and the mortise. Fig. 545 illustrates a machine of this class, with boring attachments. It has the advantage that it is the rotating parts which receive the shocks of impact before they reach the treadle, and these may be heavy. The counter-weight of the crank and attachments also helps the treadle, but these machines must run at high speeds, and cannot withstand the slower speeds in the form shown. In the heavy hub mortiser by the same builders (Fig. 546) the connection from the crank-shaft below to the abutment above is by an elbow-joint. As this is straightened out by the treadle the chisel-point, with constant throw, comes lower and lower. The elbow is straightened by flexible connection passing over an eccentric disk, so that the leverage of the

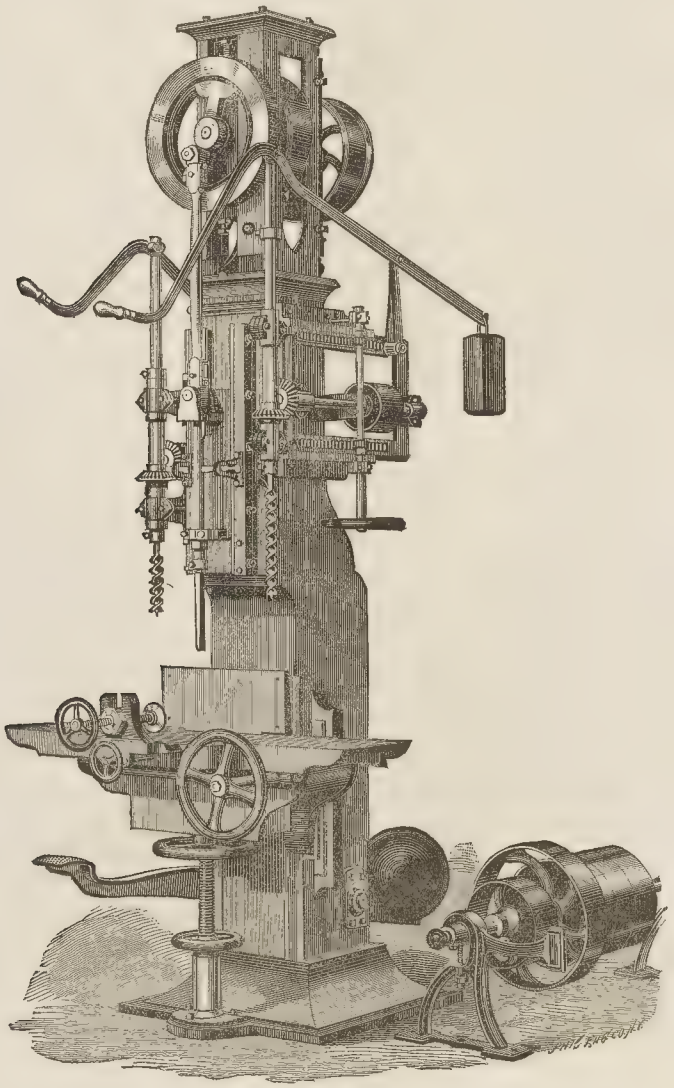


Fig. 545.

treadle is greater as the blows are heavier. The crank-shaft frame is counter-weighted. This is a manifest improvement on the earlier designs, in which the crank-shaft floated directly from the treadle. The third class of chisel-mortisers includes those in which the motion of the bar is made variable by varying the length of the lever-arm which drives it. This may be done by varying the crank-arm, or, as in Fig. 547, by making the crank swing a pivoted lever, upon which slides the wrist-block which drives the chisel. The position of the block is controlled by the links from the treadle, and the stroke may vary from nearly the full stroke of the crank to almost zero.

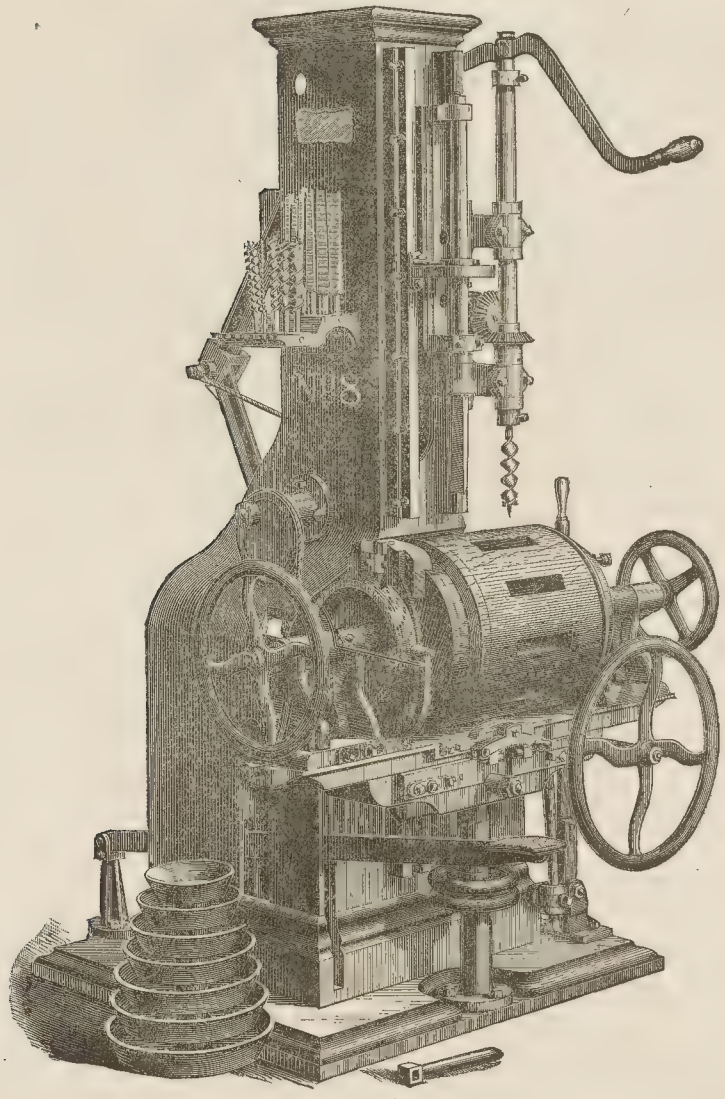


Fig. 546.

But this variation takes place on both sides of the central position of the chisel, and the stroke must be twice as long as the depth of the mortise when measured from the position of rest. This limits the speed of the tool, and multiplies the number of joints between the bar and the crank-pin. The fourth class includes the designs of the type shown by Fig. 548. In this form the stroke may be graduated from zero to the full throw of the crank, but the still point is when the chisel is at the top of its stroke. The variation is caused by varying the length of the line between the crank and the head of the chisel-bar. The connecting-rod is jointed in the middle, and a third

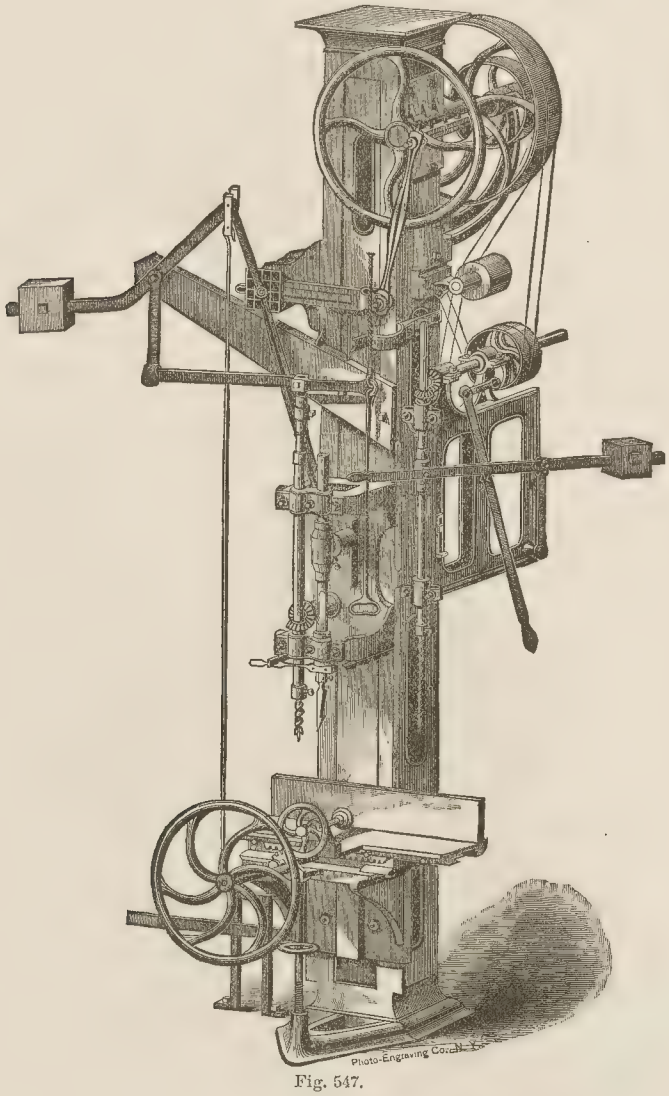


Fig. 547.

link may throw the former into an elbow or straighten it out. When the rod is bent, the thrust of the first link is entirely oblique to the travel of the bar, and it causes no motion in the latter. When the links are straightened, the whole thrust goes into the bar. At intermediate points a component is absorbed in the third link, and the rest causes graduated motion in the bar. The third link is controlled by the foot-treadle from the end of the crank shown, which is counter-weighted. The boring attachment on the left slides outward by rack from the hand-wheel for general boring. The other at the right is in the line of the chisel for mortising.

The fifth class of chisel mortisers includes those which have a progressive downward motion of the chisel-bar to the required depth from a still point, but are without flexed joints in the links. Such a one is shown by Fig. 549. The chisel-bar is worked from the front end of a vibrating beam, pivoted at the middle. At the rear end of this

beam is an oscillating box, to which fits a lever which is worked by a connecting-rod from the wrist-pin on the balance-wheel. This second lever is adjusted for position in the oscillating box by a rack and pinion. When the box is near the center of motion the chisel-bar is up, and it has no stroke. As the lever is drawn forward the stroke increases in length but diminishes in power. The boring-mandrel has a special belt-motion, by which it can be driven either in line of the chisel or at any point across the work. In another somewhat similar design, instead of

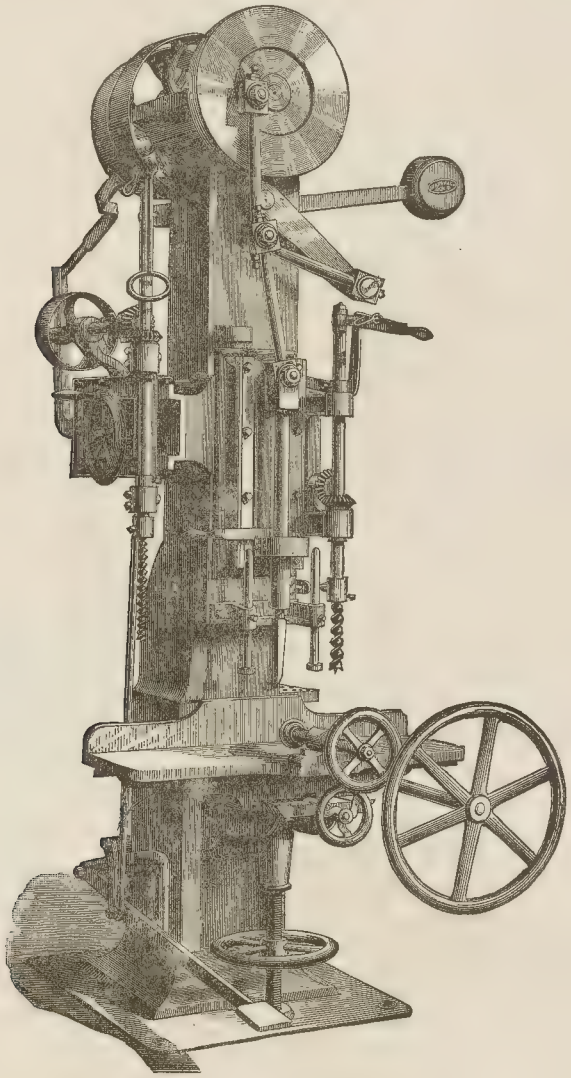


Fig. 548.

shifting the second lever, the connecting-rod is jointed as in the fourth class, and the third link is moved from an arm which carries a quadrant with worm-teeth driven by a worm. As the worm is turned in one direction the links pass into an elbow-joint, and the motion of the chisel grows less and less. The worm-shaft is turned by a belt from a shaft driven by a three-cone combination, the friction being by paper on iron. The jar of the links is received by the worm, which is held from slipping on its shaft lengthwise by a stiff steel spring. This receives the shocks and none reach the foot-treadle. A counter-weight puts into action the cone, which lifts the chisel, and the downward feed is given when the weight is overcome by the foot of the operator on a treadle. The flexed elbow-joint takes up the bar to a point $1\frac{1}{2}$ inches higher than the top of the stroke when the links are straight. The reversal of the bar is effected by a round belt upon a grooved wheel. This belt is prevented from acting during the stroke by four stops upon the face of a horizontal wheel. These stops are alternately in different planes, and the motion of the

treadle releases one stop but catches the second. This causes a revolution through 90°. The release of the treadle releases the second stop and catches the third, whereby the bar passes through 90° more, or through a half revolution in all. The reversal is thereby always effected in air, when the chisel is up, and may be entirely automatic.

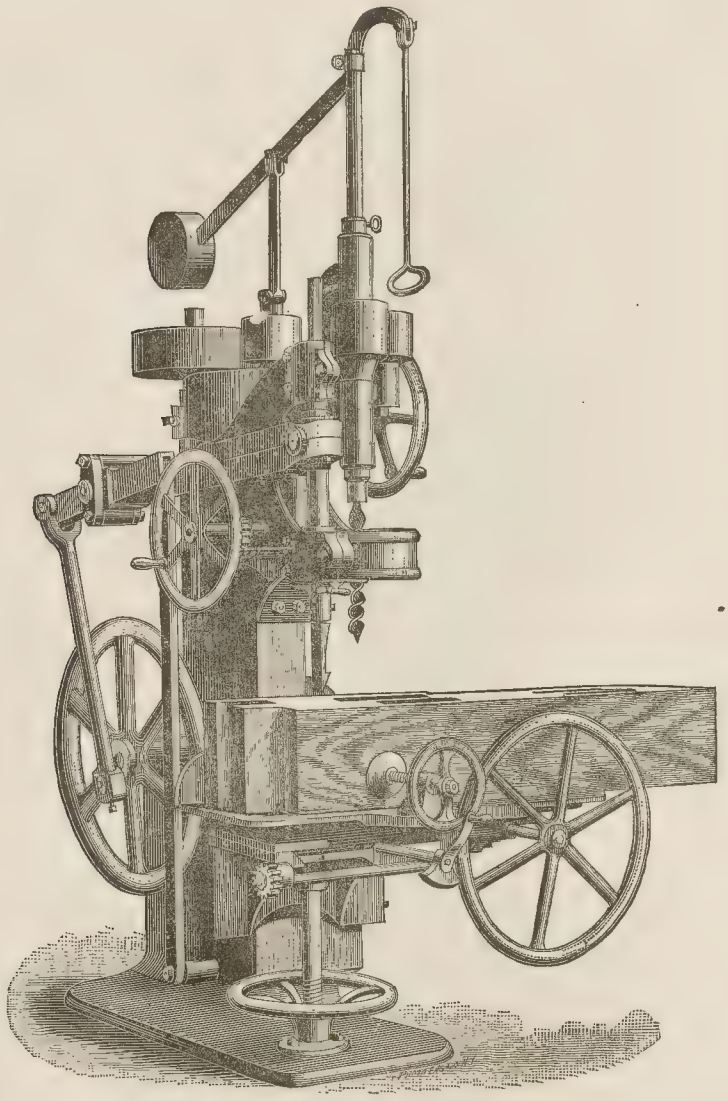


Fig. 549.

The mortising-machines belonging to the various classes illustrated give a wide range of adaptation. With one type or another every class of work can be satisfactorily done, and the details of their construction are of a high grade of mechanical excellence.

§ 54.

BORING-MACHINES.

ese machines belong unmistakably to the class of tools acting both by paring and severing the fibers. The spur acts to sever material which is split off by the edge.

In the several mortising-machines are seen types which illustrate post-boring machines. A vertical shaft, splined, is driven by a pair of bevel-gear. A hand-lever attached to a collar at the upper end draws down the mandrel which practically feeds itself, and a counter-weight retracts the tool when the hole is made. For the larger post-borers, such as Fig. 550, a second motion horizontally is given by compounding the bracket, so that

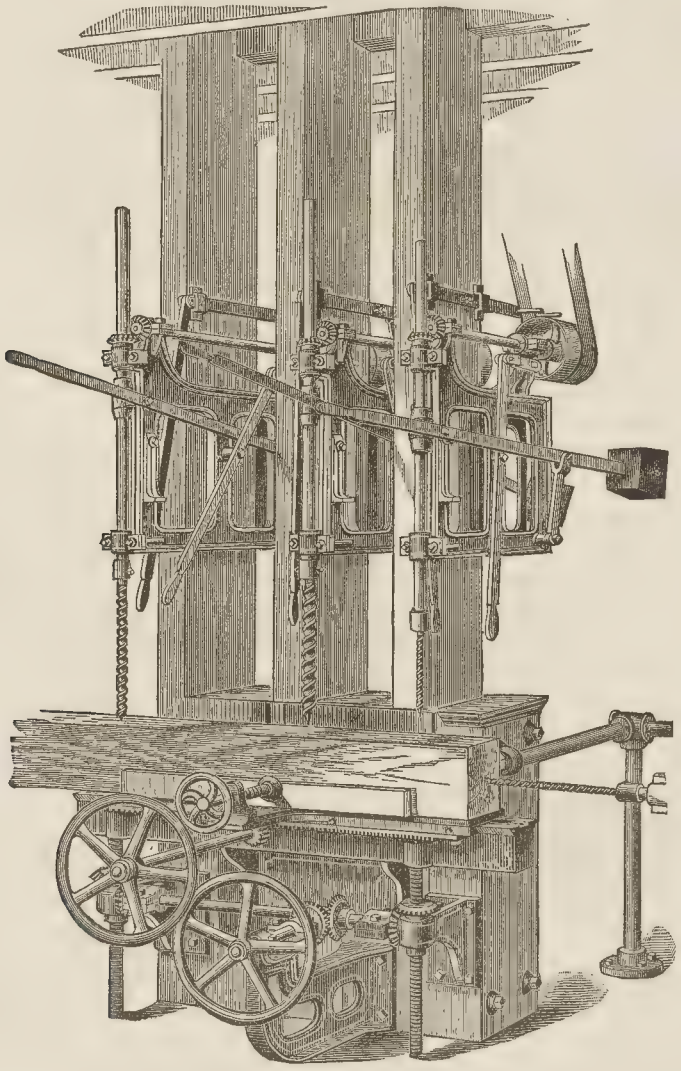


Fig. 550.

work of greater width can be bored. In the design shown, which is for car- and bridge-work, the heavy table and work is raised by geared screws, and its horizontal adjustment is made by rack and pinion. The posts may be spaced for standard intervals, or at random. The brackets are pulled forward by levers, the belt-shaft being splined. For horizontal boring in the ends of long timbers, the device of Fig. 551 is used. A similar bracket-

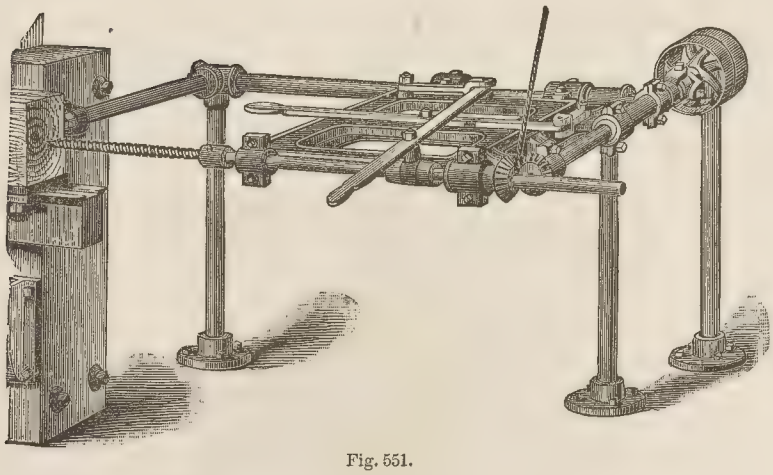


Fig. 551.

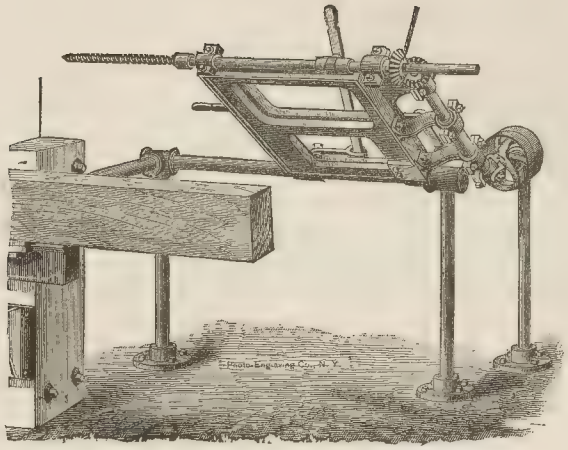


Fig. 552.

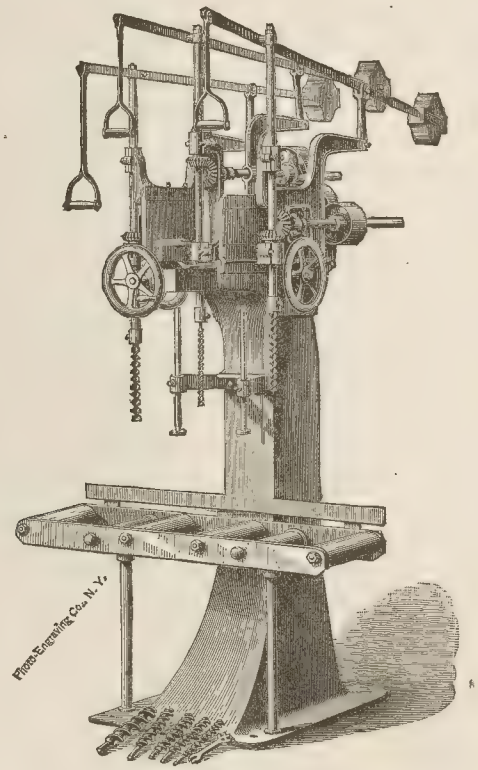


Fig. 553.

frame is pivoted at the rear and counter-weighted. The pulley-mandrel has a universal joint in it so that the whole apparatus may be lifted so as to let the timber pass it (Fig. 552). A standard iron vertical boring-machine for several bits is illustrated by Fig. 553. The two outer frames are fed forward by rack and pinion from the hand-wheels, and the central one by a screw. They are all driven by one belt, the pulley on the central shaft being larger than the other two. That causes it to turn more slowly, and fits it for the largest auger of the set. The table has friction-rolls for the easy handling of the heavy work for which the tool is adapted. A type of vertical borer, designed to be secured to a post, is shown by Fig. 554. The mandrel is driven by a quarter-twist belt, and has no horizontal traverse. The pressure for feed may be by hand or by foot. For horizontal boring in car and large work the rotary mortisers may be applied, or tools with the same capabilities.

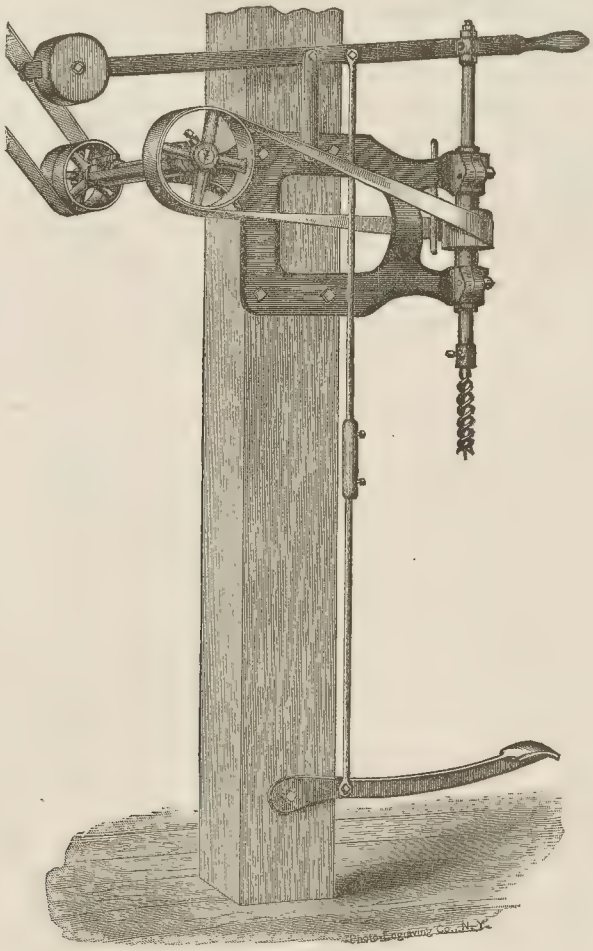


Fig. 554.

Figs. 555 and 556 show their general construction. A counter-weighted slide carries the boring-arbor, and gives vertical adjustment by screws and hand-crank. Power is furnished directly by belt over guide-pulleys or from the counter in the mean horizontal plane. Fig. 555 shows the use of a stop for gauging the depth of holes. The feed is by the handles shown. A machine for angular or radial boring is illustrated by Fig. 557. The belt is tightened by a pulley with a weight hung in a slack bight overhead, by which any elevation or angle may be secured for the mandrel. This machine meets a need in car- and bridge-work, where truss-rods are to pass obliquely through the ends of the timbers. It will also bore with the grain on the ends of work. For the smaller work of miscellaneous shops, what are known as universal machines are approved. As in the larger types, these are vertical and horizontal.

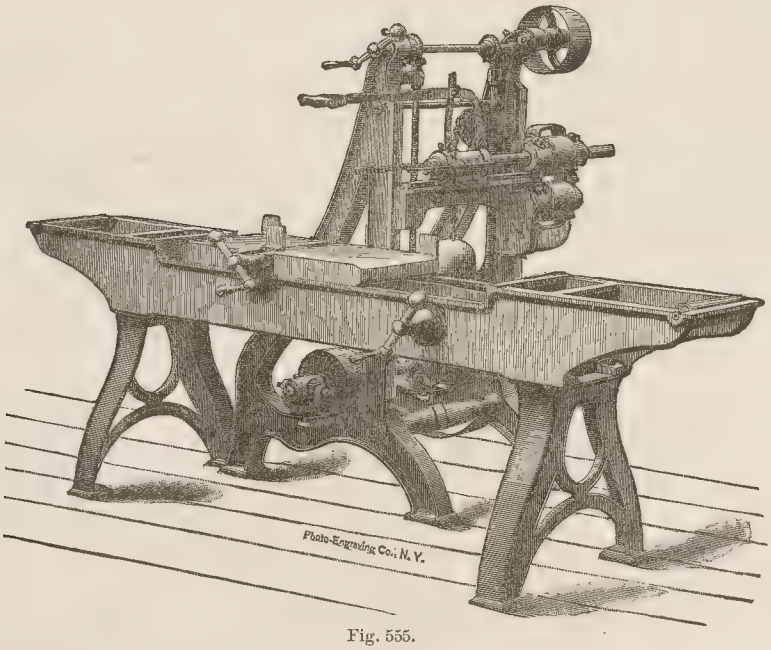


Fig. 555.

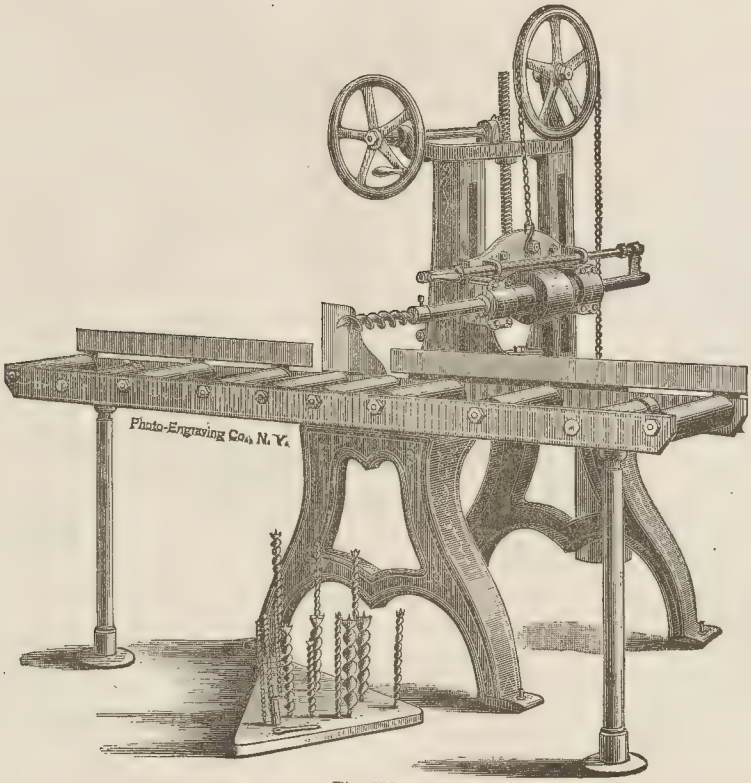


Fig. 556.

Figs. 558 and 559 are types of the vertical machines, which are driven by a belt over guide-pulleys. Provision is made in most of these machines for giving two or three speeds to the mandrels to adapt them for augers of different diameters. The tool is brought down to its work by a foot-treadle, so as to leave the hands free to hold the less stable work. The tables are adjusted easily, by rack and pinion in one case, and by a screw in the other The universality is attained by compounding the tables. In Fig. 558 the upper part of the table-upright rotates to any horizontal angle, and the sectors permit the table to stand at any angle with the horizontal or vertical planes through the bit. In Fig. 559 the table is gibbed to slides, and a double set of sectors is required. There are many smaller vertical borers which have the tables without universal capacities. Many of these have the table rise by a foot-treadle, or the spindle may descend.

The horizontal universal machines (Figs. 560 and 561) require no guide-pulleys, and the cone-pulleys may be on the mandrel. Stop-gauges or collars may gauge the depth of holes when the mandrel is pressed forward by the jointed levers from the counter-weighted treadle. Fig. 560 gives the angles by the screw with swiveling-nut. Fig. 561 is of the same design as the vertical boring-table by the same builders. A very usual type of horizontal

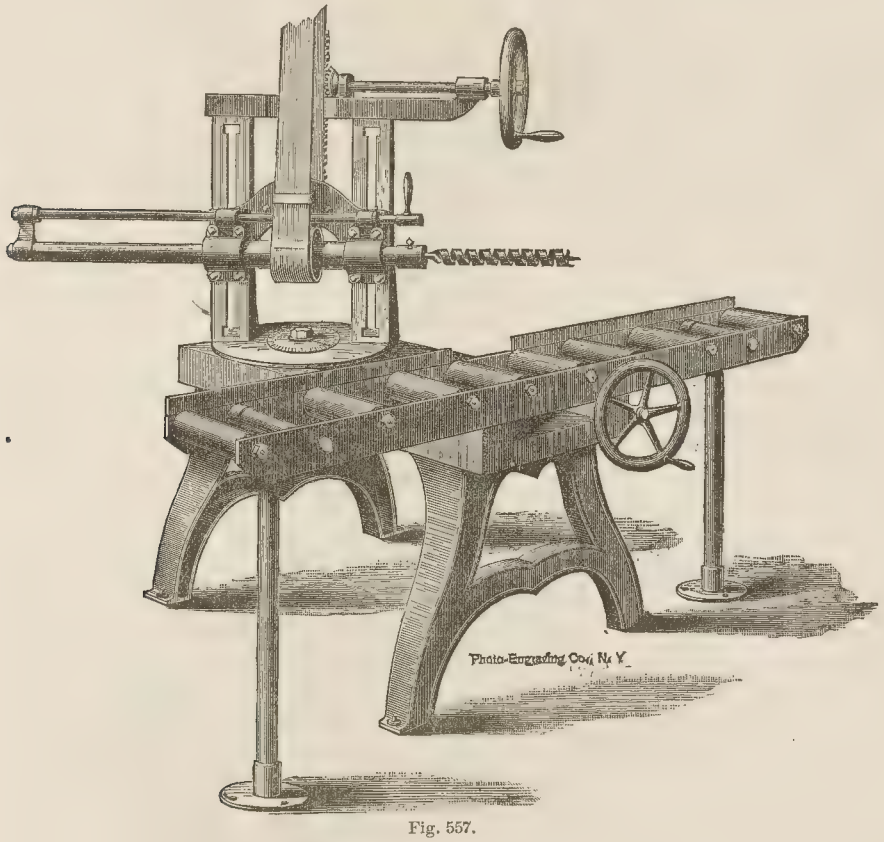


Fig. 557.

boring-machine is illustrated by Fig. 562. It is for work of medium size, and the vertical adjustment of the horizontal spindle is permitted by an arrangement of belt and guide-pulleys similar to that used on tenoning-machines. The tool is brought forward by a foot-treadle, acting by curved links upon the slotted lever at the back. The fence on the table is of hard wood.

In cabinet-work and in pattern-shops it is often convenient to bore two holes at once, at standard distances from each other, as for doweled work. A tool adapted for this duty is illustrated by Fig. 563. The two spindles are belted from the drum below, and are carried in two yokes, which are gibbed to the top of the frame. This top is shaped to an arc of a circle struck from the center of the counter-shaft, and the bits separate equally from a close central position by a right and left screw and hand-crank. The belts are always equally tense, and the fall of the bits as they separate is compensated for by lowering the table. The table rises and falls by the screw in front, and slides on gibbed ways to and from the bits. A stop-gauge below the table may insure standard depths.

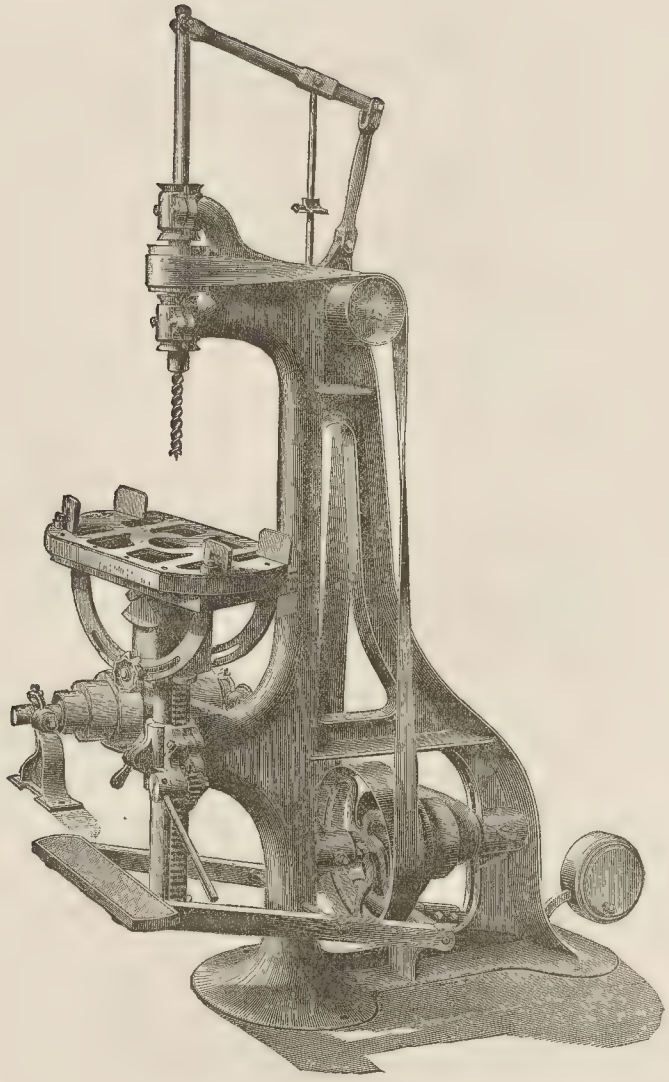


Fig. 558.

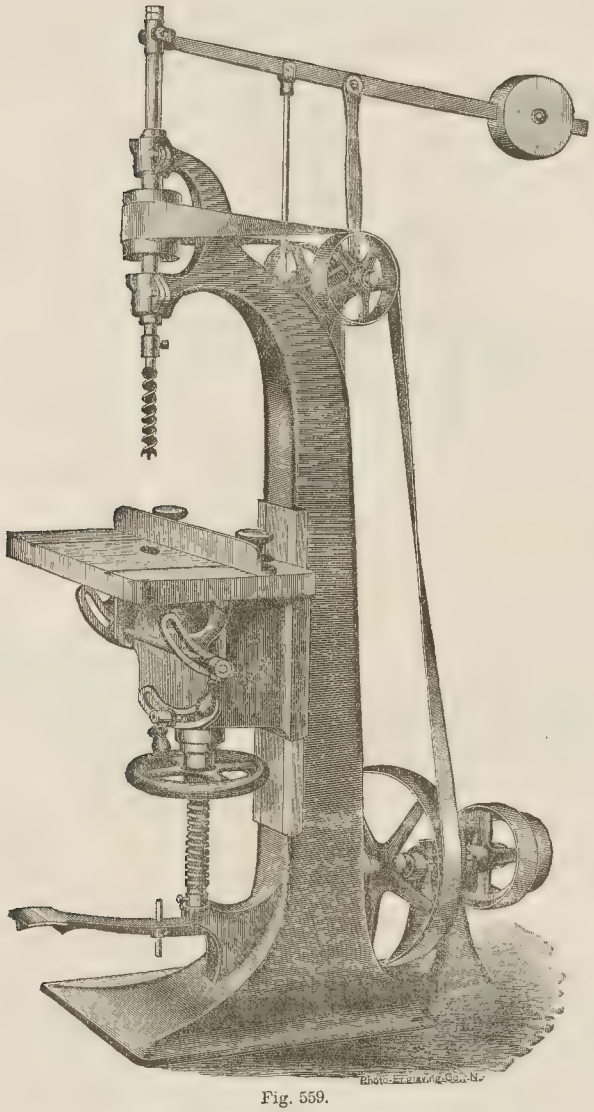


Fig. 559.

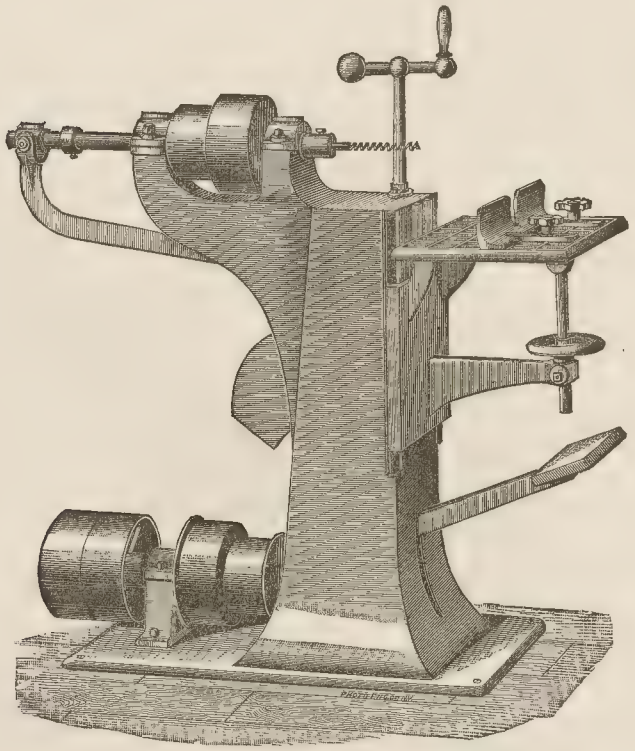


Fig. 560.

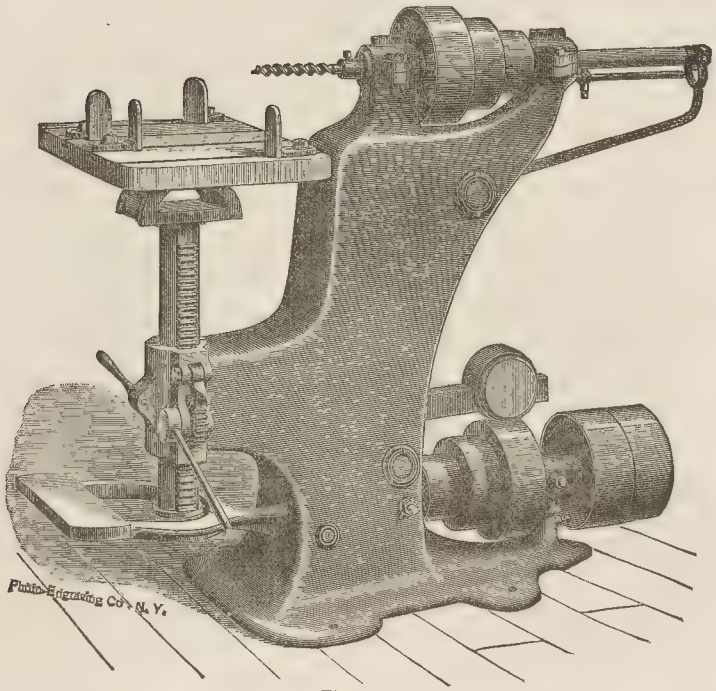


Fig. 561.

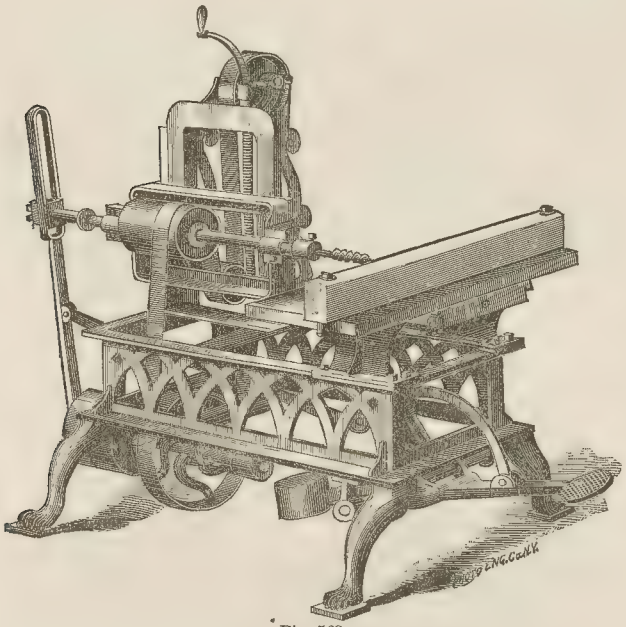


Fig. 562.

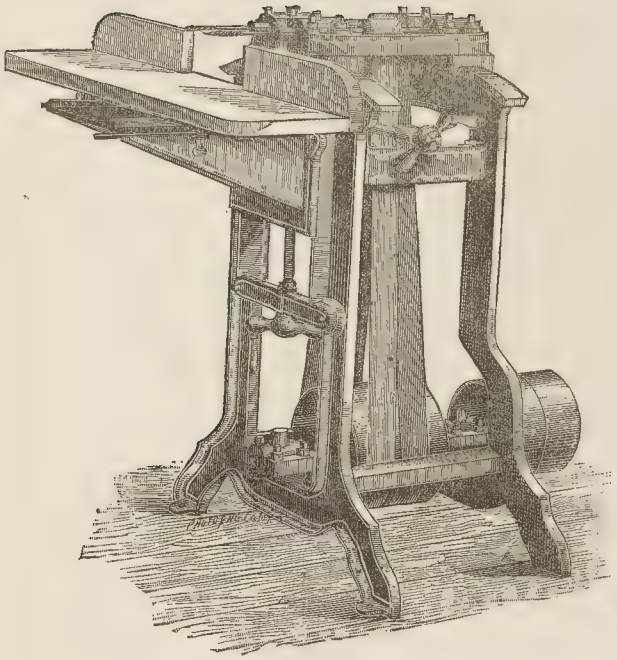


Fig. 563.

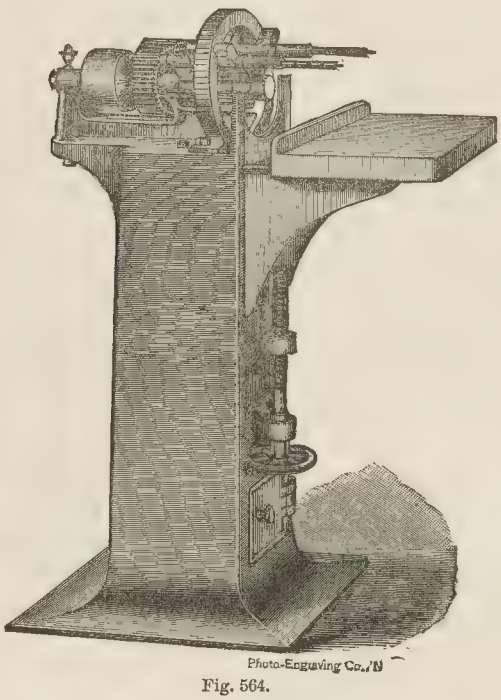


Fig. 564.

Fig. 564 shows a similar tool, but it has the two spindles driven by long pinions driven by a gear, whose center is their center of adjustment. Not only can the bits be brought as near as the diameters of the pinions will admit, but the pair of holes may be drilled at any angle between the horizontal and vertical. The holes may be spaced from 1 inch to 6 inches from center to center. The table is adjusted by screw and hand-wheel, and there are two speeds for the spindle for convenience in the variations of auger and of wood. A tool of this same double class, which illustrates very clearly the close connection between the boring-machines and the rotary mortisers, is shown by Fig. 565. It is primarily designed for boring the holes in the stiles for rolling blinds, or for mortising

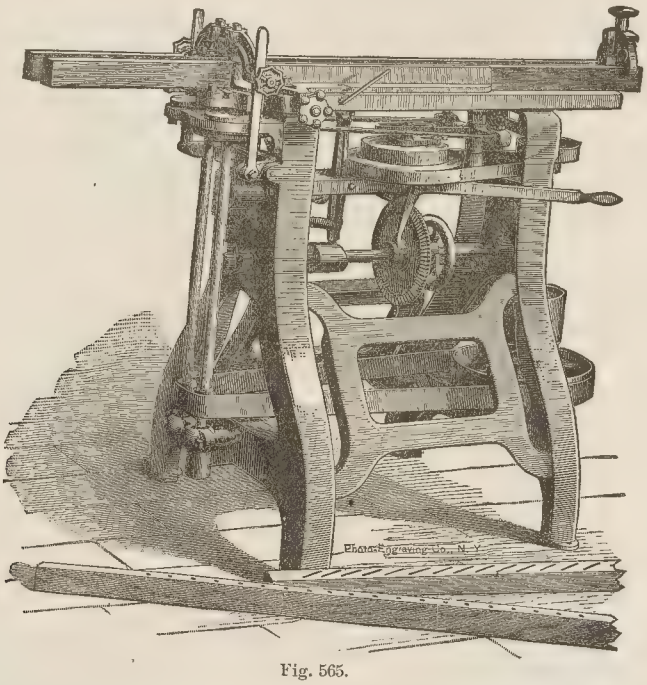


Fig. 565.

for fixed slats. Two stiles are received at once, and are fed vertically upward to a standard depth by a lever. The mortising motion is given from the wrist-pin on the horizontal disk, driven by the bevel-gear below. By releasing the clutch the tool is simply a boring-machine. The mortises may be at any angle with the length of the stiles, and their dimensions are controlled by stops. By making the cutters to work from below the holes clear themselves from chips, which might otherwise catch the cutter and break it. One hundred and fifty holes may be bored per minute, or 60 mortises may be made for stationary slats, and a manifest economy is thus effected.

The mechanical details of the boring-machines of to-day are of high grade. The spindles are of steel, and the thrust of penetration is borne by rawhide washers or by steel or composition steps. Many of them illustrate provisions to take up wear.

§ 55.

I.—MACHINES ACTING BY ABRASION.

SAND-PAPERING MACHINES.

The sand-papering machines correspond to the polishing-wheels for the metals. Their function is the production of a smooth surface upon the woods, that the varnish may produce an ornamental finish. For curved and cylindrical surfaces this power sand-papering has to be done by an endless belt. Upon this an adhesive like glue is spread, and sand or emery of the proper grit is dusted on the surface. There are usually mountings for two belts to employ two operatives and devices for maintaining the proper tension of the sand-belts. There is a great deal of grit and dust given off from such machines, and the boxes must be specially protected from the entrance of abrading particles. This type of machine is trying to the operators, but is required for some types of work. For flat surfaces, such as occur in door, cabinet, and piano-work, a bracket-machine is used such as is shown by Figs. 566 and 567.

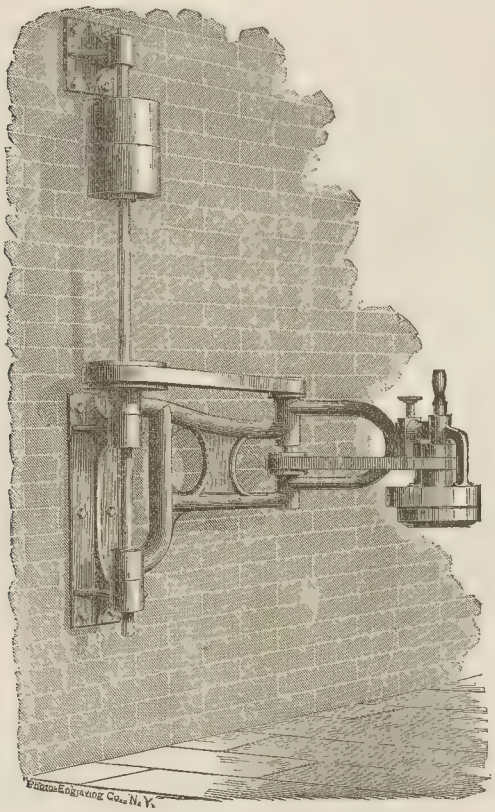


Fig. 566.

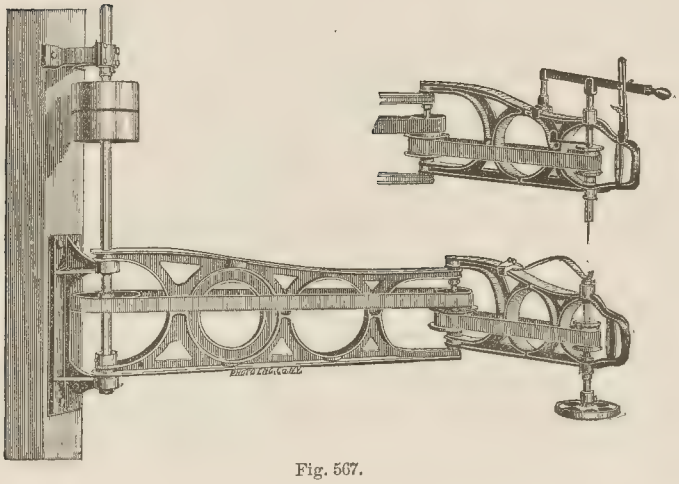


Fig. 567.

A vertical counter-shaft, with pulleys overhead or below the floor, drives a flat disk at proper speed. The bracket is divided to make an elbow-joint, with the pivot serving as idle shaft, to which the counter is belted and from which is belted the disk. This arrangement gives free motion to the disk in every direction. The adjustment of the disk for varying thicknesses is given by a milled-head screw, and the spring-handle of the disk enables the operator to gauge the amount of pressure. In the design of Fig. 567 the disk may be removed, and by a link attachment the spindle may be used for boring. The pressure of the spring is adjustable. A similar device has been applied for fancy wood-carving of large work. Where the work is unmanageable it is better than the system hitherto discussed. In Fig. 566 above the disk is an exhaust-fan on its side, and the arms of the bracket are hollow ducts, through which dust is carried away from the operator and his work. Scratches are less likely to mar the finish. Other designers put the fan on a separate mounting, with a special pipe to the disk, but this makes the arms more cumbrous.

For producing a smooth, even surface, without the circular markings of the bracket-machines, drum-machines are approved. Fig. 568 illustrates a type for hand-feed. The table is of wood, with steel lips. The cylinder is

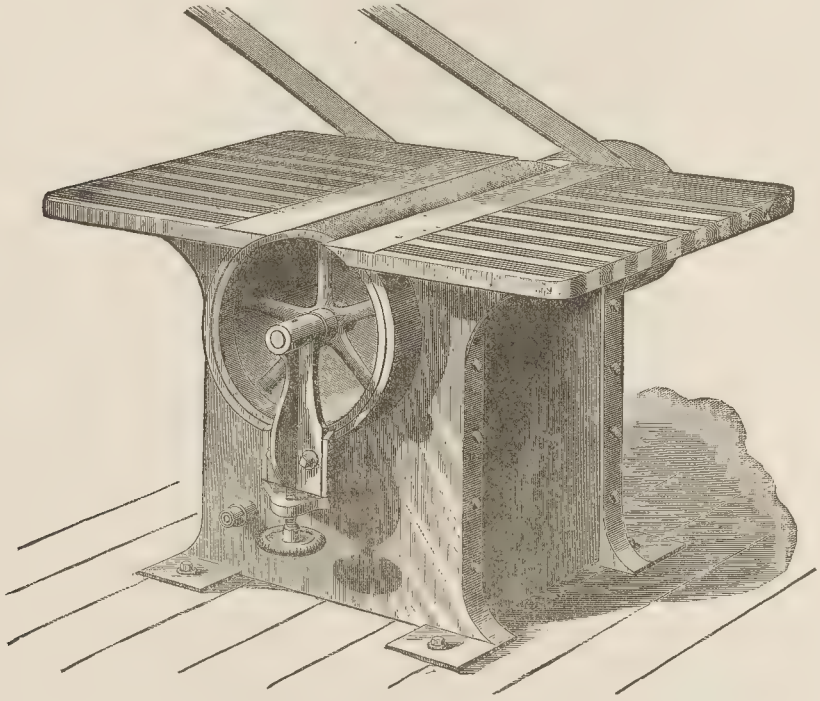


Fig. 568.

adjustable vertically, to regulate the amount of surface to be removed. The cylinder is covered with a flexible cover, which bears the abrading material. The box frame is nearly air-tight, and an exhaust-fan takes away the dust. There are advantages, however, in the regular feed when the gear is driven by power. Fig. 569 shows a machine where the feeding is done by rubber bands, driven by flanged pulleys and the geared rollers. The design of Fig. 570 has the feed given by pairs of smooth rollers, which are adjusted by screws connected by gearing-chain, and are driven from the cylinder through an idle belt-shaft. The elasticity for the pressure of the feed is obtained by rubber springs. For furniture, coffin, cabinet, and piano work these machines of the various types do much better and more satisfactory duty than can be done by hand-labor. They occupy an important place in shops which demand a high finish upon the work they turn out.

The emery-wheel has been recently applied to shape as well as to finish wood surfaces. A coarse or porous wheel—known as a "blubbered" wheel when vitrified—revolves rapidly against the work, which is slowly rotated. Hard woods especially are amenable to this treatment after the roughing-cuts of rapidly-fed machines. Whip-stocks have been smoothed by this process with marked success. But it may be laid down as a principle that unnecessary power is consumed when purely shaping processes must reduce to dust the material they remove.

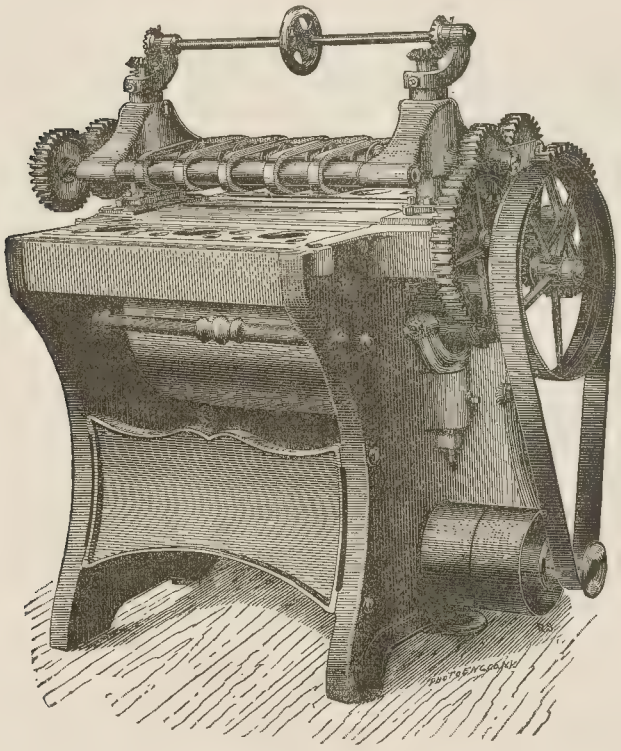


Fig. 569.

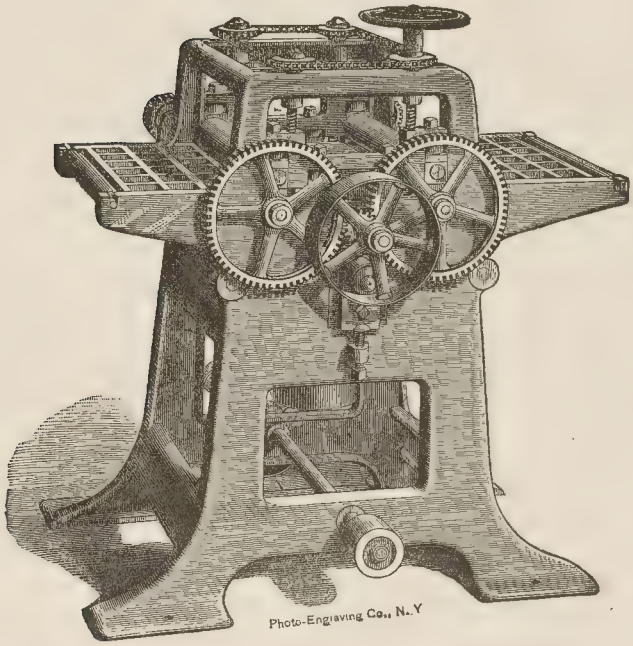


Fig. 570.

§ 56.

The same considerations have acted as in the first part to deter from detailed allusion to the linear capacities of the tools described. They are accessible to those who look for them. But it is difficult to leave the class of wood-working machinery without referring to two points, which are indicative of recent progress. The first is the change by which the manufacture of this class of machine has passed from the hands of wood-working operatives into those of mechanical engineers. The first machines were built with wood frames, and were open to all the objections which follow from the use of a material which is elastic and is susceptible to atmospheric influences. The newer machines are more deserving of their name. They are built of steel and iron, by specialists in their manufacture, and with the same care in fitting which is called for in metal-working tools. A much higher grade of work must result, which will favor successful competition in critical markets. The second point to be noted is in part a consequence of the first. It is the gradual increase in speed of feed, and the capacity for enlarged output, due to that increased speed and to better construction. The increased output makes it possible for the purchaser to pay for a better machine, and the better machine cheapens the product by a wider distribution of the interest account and of the diminished repair account. In the earlier days the excuse for the purchase of cheap machinery was that new improvements would make it necessary to exchange old tools before they had paid for themselves. Tool-builders must always meet the demand for the grade of machine wanted, and these two causes interacted. But of later years, the better judgment of consumers, and the more advanced skill of specialist builders, has given an impulse in the direction of true progress, and the engineering community is realizing more fully the truth of the old aphorism, "the best is the cheapest".

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